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CARRYING THE WAR INTO GERMANY

Heredity, Environment, and Civilization*

Factors Controlling Human Behavior as Illustrated by the Natives of the Southwestern United States

By A. L. Kroeber, Professor of Anthropology, University of California

The first of the several factors through which it is logically possible to explain the life and conduct and customs of the Indians of the Southwest is that of race or heredity, in other words, the inherited tendencies—physical and psychical, bodily and mental—which the people that carry these customs have or might have. The general attitude of anthropologists, at least those that are primarily concerned with modes of life, toward this factor of race or heredity as explanatory of the practices or conduct of peoples, is distinctly negative. At first sight it seems as if this element could not be left out of consideration. We know that peoples differ in inherited characteristics of body—complexion, features, hair, eye color, size, head-form, and the like. Theoretically, these bodily inherited peculiarities ought to be accompanied by mentally inherited traits; such as greater or less inclination to courage, energy, power of abstract thought, mechanical ingenuity, musical or æsthetic proclivities, swift reactions, concentrating ability, gift of expression. These racial mental traits, again, theoretically should be expressed not only in the conduct but also in the customs and culture of each people. Races born to a greater activity of the mechanical faculties should possess more and higher inventions, those innately gifted in the direction of music should develop more melodious songs, and so on.

Yet ethnologists rather consistently refuse to fall back on such explanations. When it comes to using heredity as a cause in the interpretation of human institutions or national attainments, their reaction is literally an aloof one. I think I can speak for at least a majority of my colleagues on this point. What they do unanimously hold is that if there are such hereditary differences between human groups we have not yet been able to determine them. We must assume racial differences, and we know that there are also great differences in culture; but we cannot yet in any particular case prove the connection between them. We cannot yet say that heredity is the specific cause of this accomplishment, of this point of view, or of this mode of life. We cannot say that heredity is the determining factor to such and such degree of such and such customs.

I should like not to be misunderstood here. I do not deny that there is every probability that such inborn differences exist between many of the races. The point I am making is that we have as yet found no way of telling what is and what is not due to the heredity factor. The problem of science in general is to tie up one cause or factor with certain effects. The problem in the present case is to tie up definitely the specific race factor with specific phenomena of culture or group conduct, such as settled life, architecture in stone, religious symbolism, and the like; to be able to say so much of this symbolic expression is instinctive in the race and so much of it is the result of other influences. That is precisely what we cannot do; nor has anyone yet been able to find a method which he can honestly affirm will enable us to do it. This is a great pity. But I think you will agree that under the circumstances a clean scientific conscience does not allow us to do anything but to adhere to our negative attitude. When we do not know, the best thing is to say we do not know, in science as in business and in personal relations; when we are baffled, to admit we are baffled.

We anthropologists do feel that the greatest contribution we can make at present to an understanding of this factor of race is to work with the other factors with which we can deal specifically, and to push those other factors as far as we can in analyzing the phenomena of group conduct or culture. Meanwhile students in other branches of science—biology and psychology—can operate with this factor of heredity, which is more directly amenable to their techniques. Then when both they and we have made some progress, and the unknown quantities are proportionately reduced, we may be able to begin to connect the two sets of studies.

For instance, when we try to apply to the mode of life which we know these Indians of the Southwest to have had, such biological or racial facts as are at our command, we find that physical anthropologists, classifying peoples into long-headed and short-headed types, encounter both among the Southwestern Indians. They have discovered that long-headed peoples occur among some of the settled Pueblos and also among some of the nomadic tribes; and round-headed groups are also found among the settled and nomadic tribes. The Pueblo Taos and non-Pueblo Pima are both long-headed, the Pueblo Zuni and non-Pueblo Apache both broad-headed. Clearly, if the shape of the head has anything to do with the culture or mode of life of any of these peoples, the data that we possess fail to prove it. If there is any racial or hereditary reason for the differences in the mode of life, the reason is certainly a very much more subtle one that anyone has yet been able to establish.

So when we take up any other physical traits in regard to which we have information: results simply do not emerge. Dr. Hrdlicka found in a considerable number of cases, almost universally, in fact, that the pulse rate of Indians was about ten beats per minute less than that of white people—about sixty instead of seventy. While we do not know the specific cause of this phenomenon, it does seem to be hereditary. And to me it seems quite inconceivable that the physiological workings of two groups of people like Indians and Caucasians could differ so greatly without there being some reflex in their mental habits. Yet there are nomadic tribes such as the Apache that are renowned for their warlike habits, who lived as it were by fighting, and, on the other hand, there are the Zuni who are famous for their timidity and gentleness; and the pulse rates of such divergent tribes are the same. If slow pulse made for gentleness, as might be supposed, then we have the fact that the aggressive Apache has the identical pulse as the pacific Zuni. The conclusion that we must draw is that whatever the hereditary basis may be for the difference between ourselves and the Indian, it is an exceedingly intricate one, because we find all types of behavior both among the slow-pulsed Indians and among the rapid-pulsed Caucasians.

When we come to the second factor by which we might theoretically explain culture—the factor of physical environment or geography—our knowledge is not very much greater. You have probably all come across the type of Greek history which begins by giving a picture of the country—the dotted islands, blue skies, rocky headlands, and so forth—and in which the author then goes on to say something about how these gifts of nature molded Greek civilization—how Greek art is a reflection of the clear and serene atmosphere, Greek speculation the result of segregations and clashes enforced by the rugged nature of the land, and the like. Usually, I suppose, this is done because the authors feel it necessary not to start too bluntly on the thread of their story. But it is certainly a mere literary and thoroughly unscientific procedure. This is clear from the fact that each author wends his own sweet way with his explanations—letting his fancy roam through the meadow picking pretty flowers at will, as it were; and however pleasing his speculations, the next writer in that field does the same sort of thing all over again.

It is the same with the theorist who derives the culture of the Central American Maya, the civilization of China and India, the origin of Mohammedanism, from alternating cycles of arid and humid climate. Such phantasies are best met by the recognition that whoever wishes to take the trouble can easily devise any number of conflicting but equally plausible theories.

It is of course obvious that a primitive tribe under the equator would never invent the ice box, and that the Eskimo will not keep their food and water in buckets of bamboo, although we can feel sure that if the Eskimo had had bamboo carried to him by the ocean currents, he would have been both glad and able to use it. Certain materials and opportunities are provided by nature and are made use of by every people. Other materials are not provided, and certain particular customs therefore cannot be developed as they might otherwise be. But all this is only negative. Two nations have ice and one invents and the other does not invent the ice chest; two of them have both bamboo and clay, and one draws water in bamboo joints and the other in pots. Obviously, natural environment does impose certain *limiting conditions* on human life; but equally obviously, it does *not cause* inventions or institutions or progress of civilization.

We know a great many nations that have wood and sinews and flint and could make bows and arrows, but do not use them. They employ something else instead. Either their civilization has not advanced to the point where they know enough to manufacture the bow; or it has advanced so far that the bow is no longer of real utility, as among ourselves.

The determining factor then is not nature which gives or withholds the materials, but the general state of knowledge and technology and advancement of the group; in short, historical or cultural causes and not environmental causes.

The greater part of the Southwest is arid. Fish are distinctly scarce. The result is that most of the tribes get little opportunity to fish. Now we also find that most of these Southwestern Indians will not eat fish; in fact, think them poisonous. So one might say: Nature does not furnish fish in abundance; therefore the Indians got out of the habit of eating them; and finally came to believe them poisonous. At first blush this may seem a plausible reason. But in other parts of the world fish are prized as a delicacy just because they are scarce, and people feel about them very much as we do about oysters.

Then, too, fish might gradually become more abundant, or some of these tribes might move to a place where there always were plenty of fish, so that they would be living in an environment which differed from that in which their customs were formed; and yet we find that often even then they adhere to their old customs in contradiction to the new or altered environment.

We have just such a case in the Jews. It is often said that the Jew's prohibition against eating pork and oysters and lobsters originated in hygienic considerations; that these were climatically unsafe foods for him in Palestine. It is likely that this explanation is more picturesque than true. Ancient Palestine was not a country in which hogs could be raised with economic profit, and so they were not raised; and the Philistine and Phœnician kept the Jew from the coast where alone he might have obtained shellfish. Eating neither food, he acquired an aversion for them; and having the aversion, he said to himself that it was dangerous and irreligious to run counter to the aversion—just like our Pueblo Indian; and ended up by announcing that the Lord had issued the prohibition. Surely this is taking us a long way from the starting point of natural environment. This environment may indeed be said to have furnished the first occasion; but the determining causes are of an entirely different kind—psychic or cultural, however we may want to call them. If any doubt remains, we need only look at the orthodox Jew of today in our country, where environment thrusts some of his tabooed foods at him as economically and hygienically satisfactory, and he still shudders at the thought of tasting them.

If this has happened among a civilized and intelligent people, the like must have occurred innumerable times among uncivilized tribes.

The invention of agriculture has often been associated with climatic factors. The first theory was that farming took its rise in the tropics, where agriculture came naturally. Only after people had acquired the habit and moved into other countries did they take their agriculture seriously on bringing it with them into these less favorable habitats. But it is just as easy to believe that the reverse happened. The attempt has actually been made to prove from the Southwest that it was the people of arid countries who invented agriculture, necessity driving them to it through shortage of natural supplies. McGee[1] has argued elaborately for this view on the basis of conditions among the Papago of Arizona and the Seri of Sonora.

Now it is plain that mere guessing is distinctly an unscientific procedure. In this particular case we can be reasonably sure that both guesses are wrong. Agriculture did not come to the Indians of the Southwest either because nature was favorable or because it was unfavorable. It came because, for reasons which we do not now need to examine, some people in southern Mexico or Guatemala or the northern part of South America turned agriculturists; and from them the art was gradually carried, through nation after nation, to our Southwestern tribes, and finally even to the Eastern Indians. The reasons for acceptance of this explanation are numerous. First, is the distribution of native agriculture. The farming region is about equally divided between the two continents, with its middle somewhere about Central America. Then there is the fact that in Central America and Mexico there was the

*Extracts from an address delivered before the New York Academy of Sciences, at the American Museum of Natural History, April 22, 1918. This was the culminating lecture of a monthly series before the New York Academy of Sciences, all treating some phase of anthropological problems in the the southwestern United States. Republished from the *American Museum Journal*.

[1]W. J. McGee, The Beginning of Agriculture, *American Anthropologist*, Vol. VIII, 1895, pp. 350-375.

greatest concentration of population, which normally accompanies agriculture. Then, pottery has evidently spread out from the same center, and the two arts seem to go hand in hand. Other reasons might be adduced which are too lengthy to be pursued here: such as the indirect evidence of archæological exploration. It is when these various facts are linked together that the full strength of the evidence is borne in upon us.

Now what caused the first tribe in or about Central America to practice agriculture, we do not know. But we have at least done something. We have accounted for the prevalence of agriculture in our aboriginal Southwest for several thousand years; and accounted for it wholly by a cultural or human explanation without reference to climate or geography or the topography of the country. In short, the environmental factor proves to be so remote or indirect or elusive that we cannot seriously operate with it.

The third set of factors with which we have to deal is what we may call the practices or behavior of people themselves taken in the mass—their type of culture or civilization. I do not mean necessarily high civilization, but type or kind of civilization irrespective of its level. We may in this sense speak as fairly of a Hottentot or Apache civilization as of Greek or French civilization.

We have in the Southwest a rather good example of how the phenomena of civilization usually arrange themselves when we look upon them geographically. In the center of our area we find four groups of Pueblo Indians—the Hopi, Zuni, Keres, and Tewa or Tano—who undoubtedly represent the *elite* of the native culture and, to a greater or less degree, of the aboriginal civilization of the United States. These four Pueblo tribes not only built towns of stone and lived almost wholly by agriculture, but they had worked out an exceedingly complex system of religion, with symbolic rituals, a kind of rude philosophy, and the like. When we leave these town-building people and come among the nomadic or semi-nomadic tribes, we first meet the Navaho, who, we find, have a good deal of the Pueblo culture. The great stone towns are lacking, but most of the noble religion persists. A little farther from the center, among the Apache and Pima, the religion has perceptibly diminished in elaborateness and fineness. As we radiate still more, the simplification of culture increases among the Mohave, most of whose cults are of a new and ruder kind. Still farther out, on the shores of the Pacific Ocean in southern California, among the Luiseno and Gabrielino, there are still a few distinctive but isolated Pueblo traits surviving. For instance, these Indians make ground paintings, symbolic representations or pictures of the universe, which are clearly based on the Pueblo type of altar. But for every such Pueblo-type trait which they possess, there are ten or twenty which they lack. In central California, which is still more remote, we find here and there a last bit of custom reminiscent of Pueblo culture; but always only a suggestive bit, so much is it whittled down. The Pueblo culture as such, the typical one of the Southwest, has vanished. In short, we get here a set of relationships in space very much of a kind with those which the evolutionary biologist works out in time in the study of organic life.

We might represent these conditions graphically very much as Mr. N. C. Nelson[2] recently represented his findings in regard to the ancient culture of the Southwest. Without reference to the living Indians but on the basis of investigations of the remains of the past, he constructed a step pyramid which had for its apex this very region where the Pueblos are now. As he passed to each lower step, the archæological remains were cruder and less notable, and each lower step was also so much nearer the periphery. As he mentally continued to descend the pyramid, he was simultaneously retrogressing in time, descending in the scale of culture, and spreading geographically; which is but another way of representing the same thing that I have been trying to picture in terms of space alone.

We can then accurately speak of the center and chief origin of our generic Southwestern Indian culture as being located among these four Pueblo groups. Even within the narrow Pueblo region it is practically certain that at some time in the past, perhaps a thousand years ago, the intensest focus or acme of the culture was in the San Juan drainage district, where there are no Pueblos at all now; and at some later time, but still before the discovery of America, this nourishing hearth had shifted eastward and become located among the Tewa on the upper Rio Grande, where its development was arrested by the arrival of the disturbing Spaniard.

Just as agriculture and pottery have spread out from the original great Central American center, and then spread afresh farther north from the minor Pueblo center, so undoubtedly many other elements of civilization have been diffused. Some day, for instance, we may be able to prove that the Southwestern clan system and type of religion have also in the main been shaped among some of the four Pueblo tribes or their ancestors; and that these in turn derived at least the rudiments or suggestions of these institutions from Mexico and Central America.

To designate Southwestern native culture as being outright Mexican would be slovenly, because it is plain that merely its basis or stimulus was derived from Mexico, and the great bulk of its content was reshaped on the spot. Just so the Mohave or Luiseno at the fringe of the Southwestern area undoubtedly got their cultural start from the Pueblos through the Pima or Apache, but are far from being mere dependents, because they have thoroughly worked over their cultural heritage from the Pueblos into something that is distinctively their own. They represent subcenters of development of civilization that stand in exactly the same relation to the Pueblo center as this stands to the Mexican supercenter; and the relation holds equally in space, in time, and in cause.

I believe that on the strength of this illustration I can claim that we anthropologists are working out some reconstruction of what happened. We are tracing back the history of man, not on the physiological or climatic side, but culturally; and showing, in some degree, how the civilization of the American Indian came to be. We have not gone so very far, it is true; but solid progress is not made by attempting to solve at one fell swoop all the problems that confront one.

There is one respect in which the culture of the Southwest is peculiar. It is constituted of two elements that are almost polar or opposites. We have the strictly agricultural Pueblos in their towns; and we have also the nomads that separate and surround them and show the same basic culture in a different form. The Navaho and Apache live scattered in small groups in temporary villages. Acoma and Zuni were inhabited as permanent cities when the Spaniard first marched into the land. The difference between these two types of Southwestern natives is striking: and the two dwell sandwiched in between each other. In no other part of North America does there appear to be any such extreme contrast in so small an area. Ordinarily we find such differences only among tribes that are far apart, and we must travel hundreds of miles before we encounter like changes. The differences are apparently greater than those in mediæval Europe, and even there the case is not quite parallel, for the French noble and burgher and peasant were after all Frenchmen, whereas no such feeling of community of language or nationality unites the Navaho, Apache, Zuni, and Acoma.

This difference cuts across the Southwest rather deeply and shows in minor ways that may be very significant. At Zuni it is the custom for women to sit flat on the ground but for men not to do so. Sometimes the man uses an empty box; ordinarily he has built around the walls of his room a little ledge that forms a low sort of bench. In general, he no more thinks of sitting cross-legged on the ground than we do. The Navaho or Apache sits right down on the ground and crosses his legs. The various tribes are perfectly conscious of these customs. Once when I sat Turk-fashion, my Zuni companion immediately said, "Ah, you are Apache-sitting." Now, trivial as this is, such a departure of habits might easily cause different methods of serving food, or create different types of implements or of ettiquette. Even where such a minor peculiarity results in nothing further, it may often be deeply suggestive of much greater distinctions.

In the discussion of a recent address before the New York Academy of Sciences,[3] Dr. Pliny E. Goddard called attention to one of these greater distinctions. The Apache and Navaho fear the dead body as they would fear smallpox or any other contagious disease. A person that has no near kin is likely not to be buried. If a man dies in a house his people move off and abandon the vicinity. Even if he dies out of doors, his house is not lived in again. Among the Pueblos it is different. People die in their rooms and the building is not pulled down. The Pueblo's attitude toward his dead lacks entirely this element of horror that the ghost may come back and work an injury—he feels slightly or not at all certain powerful emotions to which so many other Indian tribes are intensely susceptible. Dr. Goddard suggested that somehow the ancestors of the Pueblos got rid of their dread and therefore were enabled to congregate in houses of stone. One obviously cannot build a town and then move half a mile away when the first inhabitant dies. My own interpretation would rather be the reverse of Dr. Goddard's. I should say that the Pueblos found it exceedingly inconvenient to leave their stone dwellings every little while, and unprofitable or dangerous to live in temporary ones. They therefore subdued their feeling of dread as best they could and finally got rid of it. That is, I should give the economic cause precedence over the religious one. But it matters very little whether I am right or Dr. Goddard is right. We agree, and I think all anthropologists would agree, that there is a connection between the two factors involved in this matter.

This connection is in a sense cultural, in a sense psychological. It refers to an attitude of mind bearing on other attitudes of mind or habits. And that brings us to the last aspect under which we must consider human civilization: namely, as a product of interacting cultural factors each with its peculiar psychological coloring. The mental attitude that fears the dead is more than a mere psychological phenomenon. It is something that can be formulated in terms of culture and connected with cultural elements. The Navaho's emotion is to us no longer a pure or abstract emotion, but something that we can bring into positive causal relation with directly institutional factors such as architecture in stone or wood.

For instance, in temperament the Pueblo Indians are gentle. They are an exceedingly amiable people, showing some reserve, but not the stubborn reticence characteristic of so many of our Indians. They do not evince the manly, upstanding incisiveness of the Indians of the Plains, their directness in personal intercourse, the interesting play of individuality.[4]

Now I think it is very clear that one reason why the Pueblo is less incisive and personal in his mentality, is that his culture is much more pervaded by the idea of organization. To give a brief example chosen from the field of religion, there are about sixteen hundred Zuni, or a little more than three hundred adult males. Every one of these belongs to a communal religious society. At the head of this there are fourteen sets of four or five priests each, or one out of every six men. These are ranked and grouped, with certain divisions of function. In addition there is a head priest or sort of pope, one of a college of six cardinals, as they might be called, plus a speaker or sun-priest, a woman assistant, a grand dance manager, and two bow-priests or executive officers. The remaining Zuni are divided into six groups; each of which has its own kiva or ceremonial chamber, practically also a club. Each of these clubs has its manager and keeper of costumes. All this is only part of the scheme of organization of the one communal society. Beyond this are thirteen fraternal societies, each usually containing several grades or orders, and each with its head, deputy, speaker, and medicine keeper.

Enough of such details. It is clear that on the side of religion alone the average Zuni can hardly escape holding some office or function during his life because his scheme of ritual organization is so elaborate as to provide almost as many offices as there are possible incumbents. Among the Plains Indians there is nothing like this. Such simple forms of organization as they possess are absolutely rudimentary in comparison.

What I am trying to show is that these culture phenomena must have a reaction on the individual's psychology. The Zuni does not think of an individual except as a part of a machine. Organization is so dominant in his life, so stamped all over himself and his associates, that personality is considerably stamped out of him; whereas the loosely organized Plains tribesman has every opportunity to foster his individuality and to be direct and frank in the expression of his character.

Just so, the Zuni always inclines to think of the symbolic meaning of an act rather than of the act itself. His whole mythology, the history of his people as he tells it, is more or less in this symbolic form. What is not symbolic, he has left out. If he is forced by circumstances or induced by advantage to take up new things, such as sheep or wool or woolen cloth, he says to himself: "We are indeed using them, but they are unsymbolic and not old and therefore we will not use them in religion." Then he gradually begins to use these things nevertheless, because it is convenient, but he still denies employing them. Anything that is used in any ceremonial connection must contain nothing of Caucasian origin, is the rule; but actually there are few ritual paraphernalia that do not include something which has been produced by the white man. The Zuni uses these paraphernalia but still tries to explain the fact away: again a psychological factor. After the innovation has been with him long enough, he finally manages to say to himself: "Of course we have always had this material. Our creation story tells how it came

[2] In an address on the "Archæology of the Southwest," delivered before the New York Academy of Sciences, February 25, 1918.

[3] By Dr. Clark Wissler, January 28, 1918, on "Cultural Problems in the Southwest."

[4] Dr. Robert H. Lowie, of the American Museum, in his field study of North American Indians, has gone from the Plains to the Pueblos, and has several times dilated on this very striking difference.

up out of the ground with us and was always Zuni." So he has at last made the Caucasian importation a real part of his mythological and symbolic form which he loves so much. Again, a tendency of his civilization has dictated his personal and group conduct.[5]

I think these illustrations are perhaps enough to show that a mere interpretation according to the three sets of factors with which we began our consideration does not exhaust the field. The psychic aspects are also present. And they are in some measure utilizable in explanation as soon as we can bring them into definite relation with institutional phenomena. Most of what can be done along this line still belongs to the future; but it is important not to overlook the opportunities of the future.

The anthropologist works, then, not by denying the reality of the factors of heredity and environment but by going beyond them. He does not seriously operate with them because in his own field he has been able to accomplish nothing with them. The progress which he has made and which justifies his reliance in his method and technique, has been achieved by painstaking analysis of human cultures into cultural elements; by tracing the connection, first in space, then in time, then in cause and effect, between culture element and culture element, between culture and culture; by explaining phenomena of civilization not in terms of the underlying organic constitution or surrounding nature, but in terms of civilizational phenomena themselves; with human mentality never left out, but always regarded only as it is acted on by custom and institution and reacts on them.

[5]As a study representative of this more or less psychological method of approach of culture, I might mention the famous historical novel "The Delight Makers" by Bandelier, the pioneer of Southwestern research. By no means of the highest rank as a piece of fiction, the book is nevertheless pervaded by a keener and more comprehensive insight into the psychic reactions accompanying the manifestations of Pueblo culture than any other work in the field. Of similar order, although formally much more scientific, is the essay by the late Dr. H. K. Haeberlin of the Museum, on the idea of fertilization among the Southwestern Indians. This monograph is misunderstood if it is regarded as an attempt to reduce the entire civilization of the Southwest to a single formula. It does endeavor, and on the whole with remarkable success, to view as much as possible of this culture in its relations to one of its dominant attitudes of mind.

The Stokes Bomb-Throwing Gun—I*

And Its Development

By Sir Wilfred Stokes, K.B.E.

It has been with great diffidence that I have undertaken to address you today as the third Gustave Canet Lecturer. The subject which your Council has approved of is one about which, three years ago, I knew practically nothing, nor can I today claim any deep knowledge which justifies me in standing before you and stating that I have solved any great problems hitherto obscure. My only possible justification is that I have been permitted to introduce into modern warfare a weapon of unusual simplicity and lightness which may possibly tend to exert an influence on the direction of checking the tendency to complication and intricacy which, I fear, is the vogue among modern expert designers.

The first Canet Lecture, which was delivered by Sir Trevor Dawson in 1909, dealt with "The Engineering of Ordnance," involving designs and methods of manufacture which are the outcome of long years of study and experience. The evolution of ordnance must of necessity depend to a large degree upon the process of trial and error, which naturally leads further and further from primitive simplicity. Cause and effect are not always obvious. Minds become set in one direction, and not inclined to retrace steps which have, perhaps under slightly different conditions, not been fruitful of good results.

I venture therefore to throw out the suggestion that an investigation on "The Engineering of Projectiles and their Components" could be of considerable service to the nation, because nearly all these problems are engineering problems, in the solution of which the practical manufacturing engineer is the most likely person to be helpful, at any rate, from the production point of view.

I hesitate to advocate the addition of still one more department to the long list under the Minister of Muni-

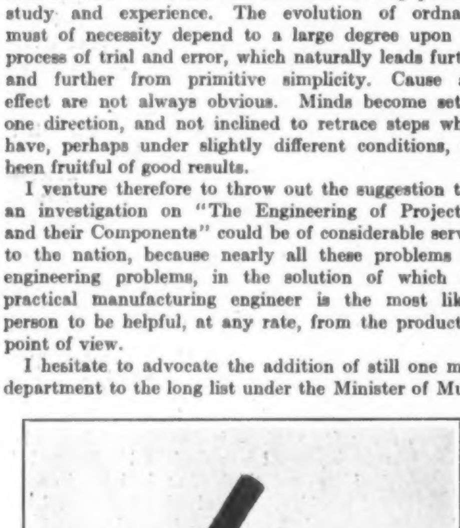


Fig. 3—First gun made

tions, but I venture to predict that if a "Simplification of Designs Department" was seriously and properly set to work, its effect, both on the rate and cost of production, would give equal satisfaction to the supply departments and the Chancellor of the Exchequer.

All this, you may think, has little or no bearing on the subject more particularly before us this evening. My retort, however, is that modern warfare has now developed into one of exhaustion of men and money.

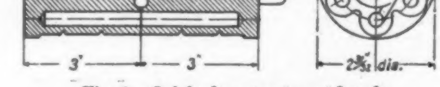


Fig. 1—Original compartment bomb

Simplicity in design means small cost and quick delivery, not to mention other advantages in the field. I would therefore ask you to pause, perhaps longer than you otherwise would feel inclined to do, in the

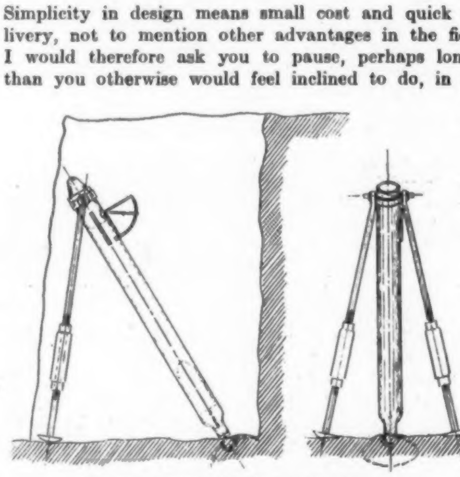


Fig. 2—Original design of Stokes gun

consideration of the Stokes gun and shell, as examples of what can be done in one direction, at least, when design is not hampered by precedent or long-established practice.

THE ORIGINAL CONCEPTION

The beginning of the present war found us quite unprepared, more particularly in weapons suitable for

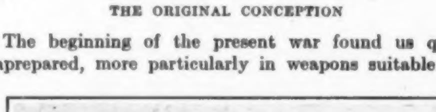


Fig. 4—First solid shell

trench warfare, and many expedients were resorted to by "Our Contemptible Little Army," having for their object the throwing of high explosives a short distance from one trench to another. When my attention was first called to the position there were four service trench howitzer designs in use, all more or less slow, heavy, and difficult to manufacture and use. It was suggested to me that we were badly off for "Frightfulness" at the front, and that our men were not having a fair chance. Could I think of anything?

What I thought of is shown on Figs. 1 and 2, which is reproduced from the information I sent to the War-office through a friend in December, 1914. Stated shortly, the proposal consisted of a cast-iron bomb with six compartments containing explosive, with a time-fuse which was lighted at the moment of firing, and which was so arranged that each of the six compartments exploded at unequal intervals. At each explosion it was intended that the bomb would be blown into a fresh position, and that, therefore, if it fell into a trench it would be very searching and demoralizing. A seventh compartment placed centrally contained a cartridge holding the propellant. The gun, or howitzer, for firing the bombs was a simple tubular barrel with two adjustable legs, thus forming a tripod. The recoil was taken by a cast-iron bowl attached to the base of the barrel.

The lower end of the barrel was provided with a pointed central rod for the purpose of firing the propellant cartridge, when the bomb was allowed to slide down to the bottom of the barrel. The main features of the scheme thus were: (1) A bomb producing successive explosions. (2) A bomb provided with its necessary charge of propellant ready for firing. (3) A simple gun without moving firing mechanism capable of automatically firing bombs as quickly as they could be fed into the muzzle and allowed to slide down to the spike at the bottom.

From this somewhat sketchy scheme there ultimately emerged the weapon and projectiles which it is my privilege to describe to you this evening, by going through the various stages of evolution which resulted from the experience and knowledge which I gradually acquired.

Looking back at what was done, I am tempted to wonder at my temerity in proceeding in the face of the attitude taken up by the experts in the subject, who with one accord "turned down" the proposals I put forward. At that time there was no Munitions Inventions Department, and, so far as I know, no machinery for developing schemes put forward in a crude form. The position today is very different

Figs. 5 and 6—First service pattern gun

from what it was in the early part of 1915, and inventors have now much more chance of obtaining a sympathetic hearing.

THE PRIMITIVE GUN

Acting on the courage of my own convictions, however, I had a primitive gun made at the works of Messrs.

*The Junior Institution of Engineers. Third Gustave Canet Lecture. Slightly abridged report from *The Engineer*.

Ransomes and Rapier, Ltd., Ipswich, out of a piece drawn tube, and a shell of a piece of bar—see Figs. 3 and 4—which gave promising results. In fact, the range so much exceeded my expectations that, much to everyone's surprise, my first shot nearly took refuge in a cottage.

Other demonstrations followed, from which emerged the following conclusions: (1) The idea of the gun was good, but in need of development. (2) The bouncing cracker bomb was not so good as a single compartment shell. (3) That my knowledge of propellants was so limited that only black powder gave anything like consistent results. (4) That as a burster, black powder should be used, in view of the shortage of high explosive and the desirability of using a cast iron shell.

Encouraged by the results so far obtained, and animated by a strong desire to do something to help to win the war, I devoted my week-ends to trials of various sorts, so that I might develop the weapon into something which would be acceptable to the authorities.

The problem of the gun itself was not very difficult. I set out with four objects in view: (1) Simplicity in manufacture; (2) simplicity and speed in firing; (3) lightness and portability; (4) quickness and ease in setting up, and change of objective.

The first barrels made were bored tubes, but it was evident that if the tubes could be drawn with sufficient accuracy, boring might be dispensed with. Arrangements were therefore made to cold-draw the barrels, and after some preliminary difficulties had been overcome the results were quite satisfactory, even without heat treatment. The lower end was bottle-necked by plant already used in the manufacture of gas cylinders.

The design of the front legs involved a good deal of thought. Eventually a simple "A" frame was made, capable of folding up when not in use, as shown in Figs. 5 and 6. The elevating and traversing screws were double threaded. The traversing screw engaged with projections formed on a gun-metal collar studded on to the barrel.

This arrangement worked well if the gun was set up with the legs approximately at right angles to the barrel. In service, however, it was found difficult to get the gun set up properly, and to meet this a modified leg was introduced of heavier design and with only half the traverse—see Fig. 7.

In this design the frame is also arranged to fold up, and to meet the extra weight the legs take apart from the barrel. The traversing screw is hollow, so that a central pin may be inserted through it and the ends of the crutch on the top of the elevating screw. This pin is withdrawn when detaching the legs—see Fig. 8. Another feature is the introduction of bevel gear for operating the elevating nut. The frame is tubular, instead of the flat bar construction in the original design, and the whole scheme is more on the lines of a machine gun mounting. The very limited traversing range is the principal drawback, and I have since put forward an improvement on simple lines which had four times the lateral range, without adding to the weight. This is made possible by the introduction of a nest of springs which takes up the shock of discharge, and thus does away with the danger of damage when the gun is badly set up. This design is still under consideration, and I fear I must, therefore, not give details of it.

The recoil of the gun when fired is taken by a pressed steel base plate—see Fig. 9—which is set up in the ground as nearly as practicable at right angles to the barrel in its firing position.

In order to increase the traverse, three cup-shaped indentations are provided to receive the base of the barrel in alternative positions. A shelf angle helps to keep the barrel in position when the ground is of an elastic character. A rope handle is used when carrying the base plate.

THE CONSTRUCTION OF THE STOKES GUN

Returning to the design of the barrel, it will be noted that the base is closed by a cap screwed on to the end, which is externally threaded for the purpose. Into this cap is screwed a short cylindrical rod projecting into the barrel. The upper end of this rod, or striker, is slightly convex, and a small nipple is formed in the center. As the face of the striker takes the blow of the projectile when it is allowed to slide down the barrel, this nipple fires the cap of the propelling cartridge, which is placed at the lower end of the projectile. It will thus be seen that there are no mechanisms or moving parts in the base of the gun, and that the firing is automatic, and simply depends on the energy acquired by the projectile sliding down the barrel. It may be remarked in passing that a trench gun, or howitzer, has a high angle fire, and a projectile will therefore always slide freely down the barrel.

The design of the striker took some time to work

Figs. 7 and 8—Second service pattern gun

out, because I started off on the wrong track. My original idea was that the propellant should be placed in a central cavity in the shell, and that it should blow out the end of the cartridge past a striker having a pointed end. This scheme had two disadvantages. First the fouling of the gun by the residue from the

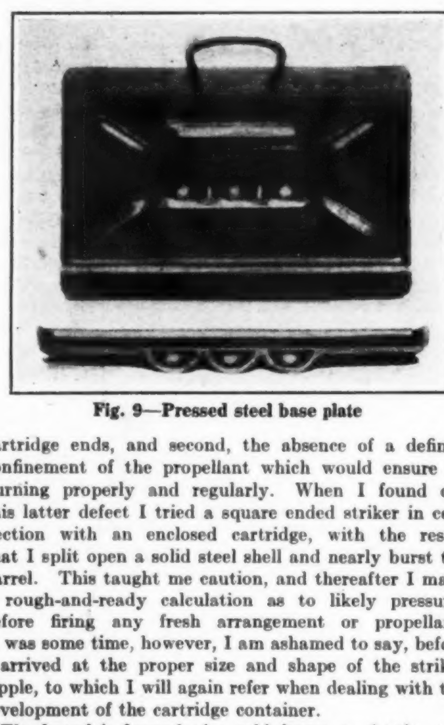


Fig. 9—Pressed steel base plate

cartridge ends, and second, the absence of a definite confinement of the propellant which would ensure its burning properly and regularly. When I found out this latter defect I tried a square ended striker in connection with an enclosed cartridge, with the result that I split open a solid steel shell and nearly burst the barrel. This taught me caution, and thereafter I made a rough-and-ready calculation as to likely pressures before firing any fresh arrangement or propellant. It was some time, however, I am ashamed to say, before I arrived at the proper size and shape of the striker nipple, to which I will again refer when dealing with the development of the cartridge container.

The barrel is formed of a cold-drawn steel tube, the thickness being determined by the pressure developed by the propellant near the base. There is a very con-

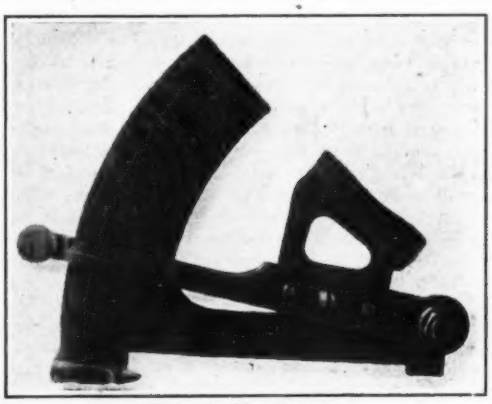


Fig. 10—Chronometer

siderable expansion chamber, which reduces this pressure to only about 1¾ tons per square inch in the case of the 3-inch gun.

This expansion chamber is important, because if ballistite—the propellant adopted—is confined in a chamber which it completely fills with it a pressure of over 40 tons per square inch is generated. The cubical contents of the expansion chamber in relation to the contents of the cartridge are such that this 40 tons is reduced to 1¾ tons when acting on the walls of the gun and projectile. A 3-inch barrel was turned down for a length of 2 feet at a thickness of only one-sixteenth of an inch. This barrel was proofed with 10 rounds of full charge projectiles, and showed no sign of deformation.

A light canvas cap is provided to cover the muzzle when the gun is not in use to keep out rain and dust. In the original guns a bolt was provided near the muzzle, projecting inward and capable of withdrawal by a lanyard. Thus a projectile could be placed in the gun and fired from a distance by withdrawing the bolt supporting it. This firing from a distance followed the practice of mortars then in use, but a little experience showed the bolt to be not only unnecessary but inconvenient for rapid fire. The present guns, therefore, have no safety bolts, and rapid fire is facilitated. The speed of firing is measured by the skill displayed in dropping the projectile down the gun and in the supply of projectiles being maintained. It is quite easy to fire from 20 to 30 rounds per minute, and I believe a record team have fired off 43 shells per minute. There is no danger of the hand being hit by the projectile.

RANGE VARIATION

The range variation can be obtained in four ways: (1) By varying the angle; (2) by varying the propellant charge; (3) by varying the expansion chamber; (4) by providing escape exits for the propellant.

(1) Varying the angle within limits is the simplest. The maximum range is obtained with the barrel at about 45 deg. To shorten the range, say, 50 per cent. the angle must be increased to about 72 deg., but at this angle the height of flight may make the effect of wind a seriously disturbing factor on the accuracy.

(2) It is therefore necessary to have resort to varying charges as well as varying angles. I originally contemplated four different charges, but ultimately these were reduced to two for the sake of simplicity.

(3) To vary the expansion chamber involves alteration to the length of the striker. This is not convenient, and after a few attempts was abandoned as impracticable. It was found, however, that there was a striker length which gives the maximum range. Increasing the pressure by shortening the striker did not further increase the range, owing to the greater escape past the projectile, due to the windage.

(4) The last alternative, viz., of providing means for allowing the escape of part of the propellant pressure was also abandoned for several reasons, among the most important being: (*a*) Avoiding unnecessary complications; (*b*) the inconvenience from excessive noise when firing; (*c*) the objection to having openings at the base when firing in water-logged trenches; (*d*) the difficulty of definite and quick control.

In order to provide an easy method of getting on to an objective a simple clinometer was designed. (See Fig. 10.) The arm carrying the bubble gives two sets of readings. On one side the range in yards obtained with the full charge is shown, together with the time of flight for fuse setting, and on the other, similar information in connection with the lesser charge. Latterly, however, owing to the multiplicity of charges and other alterations, range tables have to be used in conjunction with a simple clinometer reading angles only.

In order to enable the gun, when set up in a trench, to be laid on an object, a telescopic periscope was provided to engage with a socket on the collar belonging to the mounting. This socket has its axis parallel to the axis of the barrel. Thus, when the periscope is vertical—as shown by the spirit bubble—any object visible through the periscope and falling on the center lines is in the direct line of fire. In practice, I understand that sufficient accuracy can be obtained without the use of a periscope.

(TO BE CONTINUED)

Railway Traffic Improved by Automatic Block Signals

It has long been recognized that considerable improvement in train operation can be effected by the use of automatic block signals on railways over that possible by manual block, due to the elimination of delays caused by long and illegular lengths of the manual block system, and the greater efficiency possible in train dispatching. Figures recently published relating to the results obtained by the substitution of the automatic system in place of the manual signals on a heavy traffic double track division of an eastern railroad show that the increased mileage, in tonmiles, was equivalent to a saving of 697 trains, which is most important in view of the congested condition of our roads.

Steam Engines in the Automotive Field*

Many Advantages That May Again Bring Them to the Front

By E. T. Adams

In the general power field this is the era of steam. In the field of automotive power, even more absolutely, this is the era of gasoline.

The supremacy of steam for general power purposes has been attained only after years of competitive development. The gasoline engine has developed without serious competition and in a very short time. We therefore lack the assurance that its present preeminence in all departments of the automotive field may not be based on causes other than superior fitness for the service, such, for example, as a condition of the oil industry, now outworn, or upon the initial unreadiness of the other types of engines.

At the present time the question as to the relative fitness of the gasoline as compared with the steam engine for automotive service is receiving most serious attention. New developments and new inventions in steam engines have revolutionized the status of steam at the very time when the oil industry has reached a position absolutely the reverse of that which led to, and fostered the growth of, the gasoline engine. Two interrelated economic developments are especially noteworthy. First is the tremendous increase in the demand for automotive power. The use of the automobile has become universal, the use of the truck is at the beginning of an era of expansion which may prove equally great, and the farm tractor marks the beginning of a demand greater than all the others. The farm is the greatest single user of power, few people realize how huge a portion of the earth's surface must annually be cut into slices, turned upside down and pulverized to form a seed bed, and the expenditure of power which this involves. The excellence of the gasoline engine has led to its adoption for this and for other service for which it is economically unfitted, and we are fast working toward a condition where gasoline alone is not produced in sufficient quantity to meet the demand.

Second is the fuel situation. When the automobile industry was young the oil industry was dependent on the use of oil for light, and gasoline was a by-product—cheap, abundant and of excellent quality. Today the oil industry is based on oil for power, and gasoline is its foremost product. The supply, even with lowered quality and new processes of manufacture, is not equal to the demand, and the price is too high for many commercial uses. There will be some gain due to the perfection of vaporizing types of carbureters which will permit further lowering of the quality of gasoline, and some gain due to increased attention to economy, but the growth of the use of power in this field will be greatly hampered unless there is an increase in the quantity of fuel available far greater than can be expected from this source alone. This means the use of oils other than gasoline, and of methods other than carburetion and burning in an internal combustion engine.

The steam-driven engine is the type which most readily meets this condition, and its use will receive a further impetus because the demand for gasoline is a seasonal demand and a steam unit using unpurified kerosene or similar light distillates will use these by-products of gasoline manufacture during the season in which they are produced. These by-products are produced in great quantities, are relatively cheap, and furnish an ideal fuel for the small-power steam boiler.

ADVANTAGES OF STEAM UNIT

The steam unit has many advantages for automotive service. Its high torque at low speed, its overload capacity, its smooth, flexible speed and power control have remained the standards of excellence, reached for but never attained by any gasoline engine. The connection from engine to axle is simple and direct, without clutch, reverse or change gears. Steam is available at full boiler pressure and for practically full stroke to give torque to lift a loaded rear axle slowly and gently from a rut. Ahead and reverse follow the movement of a single lever, and acceleration and hill-climbing capacity hitherto unknown are at the operator's command.

High steam pressures and temperatures have been the rule, but a light, compact engine construction and high economy are attainable with steam pressures between 400 and 500 lb. gage, and thereby we avoid the tendency to carbonize the lubricating oil which is found at higher temperatures. There has been much interesting speculation on the economies due to the use of higher steam pressures and the best division of a given total heat between superheat and the temperature due to evaporation. But in the small units here considered, practical considerations, such as have been outlined, will doubtless govern design.

The chief force which is bringing about the increased use of the steam engine is its superior fitness for automotive service, especially in the commercial field. First, in truck service the upkeep of the gasoline truck, even with expert service, is now beyond reason and is a serious handicap to the business. Overloading and incompetent handling are blamed for this condition, but, practically, overloading is not preventable, and starting from a bad position is an unavoidable hazard. Racing the engine, coupled with the sudden application of the clutch, is the only answer to these conditions which the gasoline engine affords. The result is destructive to both power plant and transmission. The steam engine meets this situation by using steam for practically the full stroke of the piston and at any pressure which the tractive power of the wheel will permit. The available mean effective pressure on the steam piston under these conditions is fully five times the maximum available with a gasoline engine, and the engine speed for the same torque may be correspondingly low. With the steam unit the load is picked up gently, exactly as a locomotive starts a train. This tends toward low cost of upkeep.

SIMPLICITY OF TRANSMISSION

Another point in favor of the steam unit is the extreme simplicity of the transmission—one pair of bevel or spur gears or direct drive on the worm shaft is all that is required for light and moderate power work, with one additional reduction for heavy work and tractor service. There is no clutch, no reverse gear, only a simple direct drive from engine to axle. This again tends toward low upkeep and long life.

In early construction the engine naturally followed locomotive or marine lines. Modern steam engines are preferably of the multiple-cylinder type, designed for quantity production, using the tool equipment and shop methods of the modern gasoline-engine manufacturer. They are carefully balanced, are light and simple and capable of as high speed as may be desired. The uniflow type is largely used because of its simplicity and its high economy when operated non-condensing. Because of the high steam pressure, the most economical mean effective pressure is about the same as full-load mean effective pressure of the gasoline engine, and for the same power the cylinder sizes are about the same in the two cases. With this construction piston and valve require but little lubrication, the amount of lubricating oil necessary being far less than that used by older types of steam or by modern types of gasoline engines. The pistons and rods follow automobile practice. Alloy steel and aluminum are freely used and ball-bearing construction is employed where possible. Crankshafts and pins are oiled by a forced lubrication system, bearing areas are ample, and the labor cost for adjustment and repair is naturally extremely low.

TYPES OF BOILER DESIGN

Boiler design exhibits greater variety than any other portion of the steam unit. The cylindrical fire-tube type, both with and without a water leg, have their advocates. The ordinary flash type is in use, but not so much in favor, because, among other things, of its especial tendency to carbonize any lubricating oil introduced with the steam. Tube boilers with natural or forced circulation are popular and effective. A forced-circulation, contraflow-tube type seems especially commendable in that it may be forced to almost any degree and is therefore responsive, light, compact and economical. The stack temperatures are readily brought down to 50 deg. above feed temperatures; the superheat is under good control and danger of burning or injury to the tubes is negligible. One advantage of the tube type is its absolute safety from destructive explosions.

All these features exhibit a very great advance over older constructions. They are popular because of their economy and safety, and because all these improvements tend toward longer life and lower cost of upkeep.

The furnace is the most important feature of the modern unit. All precedent is swept aside. With a light power oil as the established fuel there is no excuse for following old practice and merely firing oil into a combustion space originally designed for coal, and in later designs this is not done. First are established proper conditions for burning the oil; second are established proper conditions for utilizing the heat thus generated, and these are then combined. In one installation this leads to a design with the furnace practically at the top of the boiler, with forced feed of oil and air; this has proved a most acceptable and desirable location.

Various methods of controlling the oil are in general service. In the oldest type the oil under pressure is converted into a highly superheated vapor, which discharges past an adjustable needle valve drawing with it an air supply, fed and controlled as in a Bunsen burner. After proper mixing the mixture is burned as it issues from fine perforations in the grate. A pilot light which keeps the oil supply superheated is a necessary part of the equipment. In spite of its high economy and its honorable record in service, this system is steadily being displaced in the more modern designs. Objection is made that under certain conditions the pilot light and the heated oil under pressure are highly dangerous, and the clogging of the control valve by carbon and tars formed by the cracking of the oil is objectionable and expensive.

CONTROL MECHANISMS

The mechanical atomizer of the type used in larger furnaces with heavier oils does not appear in use, but would seem to be well suited to the service. New systems of this general class are being tried out very extensively. These systems are important because they consider not only the proper burning of the oil, but also the commercially more important item of control. Considered as a unit, the vital control of the engine must be at the furnace. There must be control in proportion to load, in proportion to steam pressure and to maximum steam temperature, and also control directly responsive to the demands of the public. In a passenger car with a cold boiler enough steam must be generated to enable the car to be driven away in one minute. The mechanism of control, to be commercially successful, must be no more burdensome than the movement of a lever or the throwing of a switch. In a truck or tractor the demands are somewhat more moderate; but in general the steam unit must be practically on a par in the matter of starting with the gasoline unit, and the fact that in this respect also steam is now on a par with gasoline is one reason for the present impetus toward steam.

Where both air and oil are metered in under forced draft and in a boiler so flexible as those here described, it appears that a simple and entirely satisfactory method of heat graduation is to "cut in and cut out"; that is, to stop the supply of both oil and air entirely where it is desired to limit pressure or temperature, and to cut in again at full power when the pressure or temperature falls, this action of course being entirely automatic. With the safety which a tube boiler provides, a satisfactory system of water supply is a feed-pump operated by any means whose speed or time of operation is directly proportional to the load. This involves attention to the water level and occasional adjustment by the operator, but as there is no serious penalty for his failure, this seems an entirely satisfactory method—perhaps more satisfactory than a type more strictly automatic.

Next to the fuel situation and the desire for reduced cost of upkeep, this new system of control is the most important development affecting the renaissance of the steam engine in the automotive field.

The exhaust is condensed to atmospheric pressure in an ordinary type of automobile radiator. The type with wide surfaces and thin water spaces has proved most effective. In a passenger car complete condensation is secured in a small radiator often without the use of a fan. The efficiency of the radiator is reduced by excessive oil in the feed, but otherwise there are no disagreeable effects. Under these conditions fresh-water supply is needed only at rare intervals, which again is a feature that has served greatly to increase the demand for the steam engine.

COMPARISON OF ECONOMIES

It is characteristic of the internal-combustion engine that it gives its highest economy at its maximum load, with rapid reduction in economy as the load is decreased. The reverse is true of the steam unit. It results from this that under usual operating conditions the steam unit is operating at its maximum efficiency, whereas the gasoline unit is operating at only fair efficiency. These efficiencies tend to meet, and in the two cases in actual service the quantity of fuel per brake horse-power per hour should not be different, at least to any material extent.

The difference in cost between gasoline and power oil, when coupled with a reduced cost of lubricating oil, represents an appreciable reduction in fuel cost in favor of the steam unit and one of importance to the truck and

*A paper presented at the annual meeting of The American Society of Mechanical Engineers. Reported in the *Journal* of the Society of Automotive Engineers.

tractor operator. In the case of the automobile, where a small horse-power represents great mileage, this item is of lesser importance; but it lends romance to engineering to note that the joy of driving the smooth, flexible steam engine is likely to cause its extensive adoption, first in the field which commercially needs it least.

In our interest in newer conditions and later developments we should not overlook the splendid record of the builders who have long been prominent in this field. It is this pioneer work which has demonstrated the advantages and emphasized the deficiencies of the steam unit and has formed the basis on which the engineer of to-day is building.

From the earlier experience with steam power we have learned the necessity of treating the various elements of a steam-power plant as parts of a single unit. From the internal combustion engine we have learned the necessity for design on a production basis. From the oil industry we have learned what fuels are most readily available, considering both method of manufacture and distribution. And from the public we have clear-cut demands based on extended experience with both gasoline and steam in all classes of service. The designer of the steam unit, therefore, has before him unusually complete data relative to all phases of the problem.

On the part of the manufacturer and of the public there is evidence of tremendous interest. Numbers of new trucks, tractors and passenger cars are in service, or in process of manufacture or design. This effort and this demand will have a profound influence on the automotive industry. Whether it shall result in the supremacy of steam over gasoline is of minor import. The important fact is that it will surely result in a tremendous broadening of the usefulness and influence of automotive powers.

The Freedom of the Rhine*

While the German Government is indulging in eulogies of what it calls "the freedom of the seas," and is at the same time sinking hospital and neutral ships, it is quietly doing its utmost to ignore Switzerland's rights to the freedom of the Rhine and Rhine navigation.

Now, this freedom of the Rhine and of navigation thereon may seem a mere local question, but in reality it is not so. It is a European question, and the danger is that owing to the multiplicity of great events now happening, and great problems now arising, this question of free Rhine navigation may be overlooked. Undoubtedly this is what Germany hopes and expects, and that is why she has selected the present moment for endeavouring to enforce claims to which she has no justification.

Germany, in short, desires to carry out a number of vast enterprises on the Rhine between Strassburg and Basle. These enterprises consist mainly in the utilization of water-power, which would necessitate the construction of several electrical works and the canalization of the river. The German Empire has already come to an understanding with the German provincial States bordering on the Rhine to execute the works. These German projects, however, if carried out, would place many obstacles in the way of the free navigation of the Rhine.

Now, Switzerland is very anxious to use the Rhine after the war, and to use it far more than before. By means of the Rhine she hopes, in conjunction with Holland, to secure an outlet to the sea. Germany says that Switzerland has no right to raise any objections to her constructing either her proposed electrical works or the sixteen or more dams and locks across the Rhine, which would be necessary to canalize it. Switzerland, however, claims that she has a right to object to Germany's carrying on her plans. First, because of Art. 5 of the Treaty of Paris (May 30th, 1814), stipulating that "navigation on the Rhine from the point where it becomes navigable unto the sea, and *vice versa*, shall be free, and in such a way that it cannot be forbidden to anyone." Secondly, because of the international rules drawn up in 1815 by the Congress of Vienna, regarding the Rhine and its tributaries. Art. 108 of that document states that "the Powers whose territories are separated or traversed by one and the same navigable river, undertake to settle by mutual arrangement everything connected with the navigation of that river." Furthermore, in 1868, by the Rhine Navigation Act, the Treaty of Paris and the Vienna Congress stipulations were confirmed, *not* abrogated, and the navigation of the Rhine further and more definitely regulated.

Germany is now trying to excuse her action by alleging that Switzerland did not sign the Treaties of Paris and Vienna, which is true. But the Swiss rejoin that these treaties were not made merely for the benefit of the Great Powers who drafted and signed them, but also for the benefit of the small Powers, and particularly Switzerland—which, indeed, is obvious from their wording. The independent Swiss newspapers, German-Swiss and French-Swiss, newspapers not under German control, have been writing very plainly about this last exhibition of the German mailed fist. For instance, the *Stadtan eiger* of St. Gallen says: "We shall see whether in this matter Germany will again dare to act with regard to the Treaty of Vienna and the Rhine Navigation Act, so as to treat them as mere scraps of paper, as she has already done with regard to other treaties of international law."

The Vienna Congress of 1815 forbids States bordering on an international river—that is, a river whose course is between or through the territories of more than one nation—to put any obstacle in the way of free navigation; and ordains that these States are to regulate river navigation on the lines of this Congress. This was done in 1868 by the Rhine Navigation Act; and although Switzerland has not adhered to this Act, she has unquestionably a right to do so. Holland, for instance, has done so. Art. 1 laid down the principle that no obstacle of any description whatsoever may be placed in the way of the free navigation of the Rhine. Art. 30 states that no mill, bridge, or other construction may impede traffic on the Rhine. By Art. 28, the States bordering on the Rhine undertook to maintain it in a fit state for navigation. Technical knowledge proves that regularization of the Rhine is the best method of doing this—regularization which is just what the Swiss are advocating and what the Germans do not desire. The free use of the Rhine is guaranteed by the Rhine Navigation Act of 1868, and guaranteed not only to States bordering on the Rhine, but to all the world. Before the war British, and other vessels used to navigate the Rhine.

Now let us see why Germany is so anxious to treat the Rhine Navigation Act, and other international documents connected with the Rhine, as scraps of paper. What she has to gain by so doing?

First, she desires to erect electrical works to utilize the falls caused by the artificial dams which she wishes to erect across the Rhine between Strassburg and Basle. These electrical works would, it is calculated, yield 5,000,000 kilowatt-hours of energy per annum.

It would take Germany about ten years to construct the works, and in the meantime navigation between Strassburg and Basle would be completely paralyzed. Moreover, she might do the work at different times, and thus indefinitely prolong it, and consequently indefinitely paralyze navigation on the Rhine. Switzerland, therefore, would be cut off for a long time, perhaps for ever, from that outlet to the sea, *via* Holland, for which she has long hoped. Again, when Germany has finished her works, she could, and certainly would, charge a toll for the passage of each dam or lock. Moreover, the journey up-stream from Strassburg to Basle would be made 42 hours longer than it now is owing to all these artificial obstructions across the river.

Finally, Germany desires to do just what experts, Swiss and other, consider undesirable, and that is to canalize the Rhine, whereas, regularizing it is what presents far greater advantages, at any rate from the point of view of everyone except Germany.

This Rhine question has been discussed in the Swiss Parliament on several occasions lately. On June 10th Federal Councillor Ador, of Geneva, referred to the urgency of the question of river navigation for Switzerland. "Our economic independence and the extension of our trade," he said, "are bound up with the problem of access to the sea—access from Geneva to Marseilles and access from Basle *via* Strassburg and Holland to the North Sea." Another French-Swiss deputy said: "We are living in a position of economic servitude as regards our neighbours. The only way to get out of it is to secure access to the sea."

All these German manœuvres aiming at isolating Switzerland and acquiring rights upon the Rhine to which Germany is not entitled, are part of her vast scheme for "Central Europe." As M. de Rabours, an eloquent Genevese deputy, pointed out the other day in the Swiss Parliament, a press campaign is being waged in Germany at present against Switzerland's rights on the Rhine, and an attempt being made to *diviser pour mieux régner*, to divide the German-Swiss and the French-Swiss, and thus get more hold over the country. The interests of all Swiss alike, however, are bound up with river navigation, he said, and a navigable Rhone was the best guarantee which could be given for a navigable Rhine—referring to the project for making the Rhone navigable and connecting it with the Rhine, a plan which, of course, does not interest Germany, or only in so far as she thinks she might kill it. "Germany," said M. de Rabours, "is now proposing to construct a system of canals from west to east, from the Rhine to the Danube. If a river system from north to south be not opposed to this German west-to-east line, what will be Switzerland's fate? To be a tributary of Germany. What would really be to Switzerland's interest," he urged, "would be a 'River League' from Rotterdam to Marseilles, Switzerland being a kind of river navigation clearing house or clearing docks of Europe."

So far almost the only navigation that has taken place since the war between Basle and Strassburg has been a service of tugs, resumed in 1917, carrying almost exclusively coal and coke to Switzerland, and conveying chemical products to Germany in return.

To show how keen an interest Germany takes in this question of Rhine navigation, I may say that at the last annual meeting, the fourteenth, of the Association (Swiss) for Navigation on the Upper Rhine, several Germans were present, who, however, had no authority to act or speak for their Government. Here again, it was insisted that the Rhine must be regularized, and not canalized with dams and locks constructed; otherwise Dutch shipowners would take no interest in Rhine navigation as far as Basle, and Switzerland would be hopelessly cut off from the sea. The Association called upon the Swiss Government to protest, basing its protest on the Congress of Vienna and the Rhine Navigation Act of 1868, against the construction of the electrical works which Germany is planning on her side of the Rhine, and thus defend Switzerland's rights on the law of nations, and also her legitimate interests.

The *Journal de Genève*, referring to this Rhine navigation question says: "Our national programme may be summarized as follows: a free Rhine, a navigable Rhone, and junction of the Rhone and the Rhine. Here is already something worthy to occupy a whole generation."

None but those living in a country on the borders of Germany, in an atmosphere thick with German intrigue, can perhaps fully realize the importance of this German manœuvering about the Rhine. It might be thought that she would have abundant occupation now for all her energies, without troubling about constructing a series of electrical works along the Rhine to supply her with a vast quantity of power. This, however, is obviously not the case. Her leading organs find plenty of time and plenty of space for articles intended to prove that Germany is entitled to that to which she is not entitled. In other words, that Might is Right. In Berne, since the war, the Germans have rented several large hotels which they have converted into commercial offices, full of experts in all branches of trade and industry. They are flooding the country with their prospectuses, with commercial travellers and agents of all kinds, in order to impress their views upon the people. Weekly, fortnightly, and monthly papers, dealing with all manner of questions of trade and manufacture, showing the advantages of adherence to Central Europe, and expounding Germany's trade preparations for "after the war" in Turkey and the Near East generally, are sent free to all who desire them, and to many who do not. The moment an independent Swiss raises his voice against this German penetration, Germany sets her press agents in Switzerland to work to contradict him. She has no less than three well-known press agencies now operating in the country. Nevertheless, and in spite of it all, the Swiss public fully realizes the danger of Germany's Rhine plans, and none, save hopelessly pro-German organs, have a word to say in support of them.

*From *The Engineer*.

The Schoop Metal-Spray Process

By increasing the "atomizing pressure" in the "pistol" of the Schoop apparatus, metal deposits of very fine grain and high density and strength have recently been obtained according to a note by K. Matzinger, of Höngh-Zurich in the *Anzeiger für Elektroteknik und Maschinenbau*, April 28th, 1918, the *Anzeiger* is a supplement to the Vienna journal of the latter name. The pistol is a blow pipe in which the metallic bead, fused by the flame, is torn away and atomized by the current of compressed air. The ordinary working pressure of the air is 3.5 atmospheres, but the pistol operates on the injector principle, and the actual atomizing pressure was so far only 1.5 atmospheres. This atomizing pressure has recently been raised to 2.5 and 3 atmospheres without increasing the working pressure, with very promising results. A lead pipe 1 mm. wall thickness made by the improved process was filled with hydrogen at 5 atmospheric pressure while lying in water; no hydrogen escaped, while hydrogen bubbles forced their way through a lead pipe made by the old process. In another experiment plates of sheet-iron were covered with lead, one or two coatings at pressures of 1.5 or of 2.5 atmospheres. The one or two coatings of the old process did not prevent subsequent rusting of iron, but both the one coating and the two coatings of lead deposited at the higher pressure kept the plates free of rust when they were placed in water.—*Engineering.*

Ancient village of Bourré, in France

Cave-dwelling children of Bourré

Modern Cave Men

Twentieth Century Troglodytes in France

In prehistoric times, when man had to fight with wild beasts not only for food but for very life, he found a welcome refuge in grottos and caverns. But as soon as humanity had achieved some degree of progress in civilization our ancestors forsook these primitive natural shelters for more comfortable dwellings. Our readers, therefore, doubtless imagine that the "Troglodyte" ceased to exist many centuries ago, at any rate in Europe. Yet even today there may be found Frenchmen who live underground, only a few hundred kilometers from Paris, as is shown by the accompanying photographs.

The most celebrated villages of this sort are those of Bourré and of Chissey (Indre and Loire), of Brantome and of the Eyzies (Dordogne). A part of these poverty-stricken populations, in fact, inhabits caverns which obtain their supply of air partly by the numerous openings of the facade and partly by the broad chimneys cut in the rock, and whose copings, on issuing from the hill, form a picturesque alinement.

It usually happens that the excavation constituting the dwelling is very lofty and is divided into two or three stories by floors of beams and laths; sometimes, too, the entire habitation, with its stairways and its intermediate floors, is dug out of the solid mass of earth.

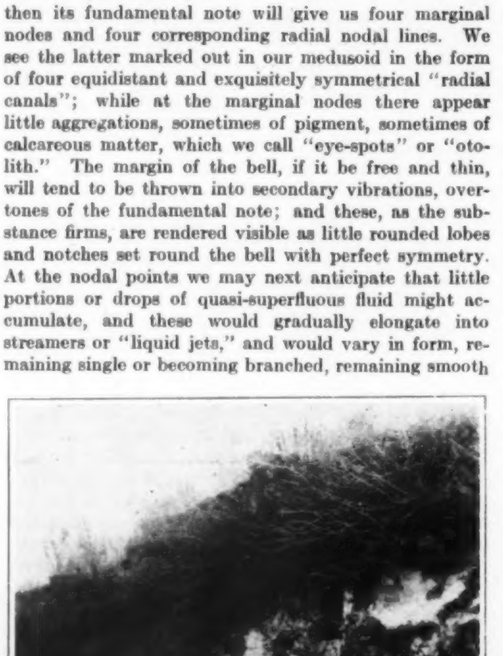
But when one penetrates into the interior of one of these troglodytic houses, one is struck by the neatness which prevails there. Against the walls which have been faired, but where one can still see the mark of the pick, are arranged old pieces of furniture and beds of massive rough hewn wood. Sometimes, however, one finds cradles of a more modern stamp, made of iron and hung with immaculate snowy curtains.

The caves of the ancient troglodytes have been hardly at all enlarged or modified; sometimes curious sculptures are to be found within, as one of our pictures indicates, and in turning up the earth one comes across the bones of the great bear or of the reindeer which served our predecessors for food. Thus the prehistoric age of the cave men has been prolonged into the midst of the twentieth century.

Medusoid Bells

Just now the sea is full of little tiny bells, and, what is more, they are *all a-ringing*. A few weeks ago I watched some of them developing. Precisely how they do so is not very easy to see, but they develop with amazing rapidity. It is hard indeed to believe that they "grow," cell by cell; rather do they seem just to "come off" the parent stock, one after another, like little curiously formed drops or droplets. They seem to me to be formed *as a whole*, and, apparently (to use Adam Sedgwick's words, written more than thirty years ago), whatever cellular elements they contain "must be regarded as a multiplication of nuclei and a specialization of tracts and vacuoles in a continuous mass of protoplasm." If this be so, we may throw conventional embryology aside, and conceive of the little bell as being automatically conformed by some physical process akin to the many beautiful phenomena of ordinary drops. But let us pass this problem by for the moment, and merely inquire what modifications of structure would be likely to ensue if the little bell, once formed or partly formed, were to be in a state of vibration; and if at the same time its semi-fluid or colloid and very heterogeneous substance were such as to permit easy transference from place to place of its heavier or lighter particles.

Suppose the little bell to vibrate as other bells do, then its fundamental note will give us four marginal nodes and four corresponding radial nodal lines. We see the latter marked out in our medusoid in the form of four equidistant and exquisitely symmetrical "radial canals"; while at the marginal nodes there appear little aggregations, sometimes of pigment, sometimes of calcareous matter, which we call "eye-spots" or "otolith." The margin of the bell, if it be free and thin, will tend to be thrown into secondary vibrations, overtones of the fundamental note; and these, as the substance firms, are rendered visible as little rounded lobes and notches set round the bell with perfect symmetry. At the nodal points we may next anticipate that little portions or drops of quasi-superfluous fluid might accumulate, and these would gradually elongate into streamers or "liquid jets," and would vary in form, remaining single or becoming branched, remaining smooth



A dwelling at Chenu (Sarthe)

or becoming annulated or beaded, according to the surface-tensions between their substance and the surrounding medium. In any case, they would agree in number and position with the nodes, and where these were numerous and of successive orders, so also would the tentacles tend to correspond in order and magnitude. In short, several of the most important and most conspicuous features of the little "bell" would follow from the simple hypothesis of its intrinsic vibration. Fitzgerald and others have suggested that we may, in like manner, ascribe to vibration the minute and exquisite patterns of many diatoms; Dendy and Nicholson have made use of the same hypothesis to explain the characteristic form of certain sponge-spicules. I have a strong idea that the principle is very far-reaching indeed, and that its bearing on morphological problems will be found to be of great importance.

Our little medusoid is but a single instance, a single type, out of very many. All through the Cœlenterata, in polypes and corals of all sorts, we are confronted by the phenomenon of geometrical symmetry, and corresponding numerical symmetry of parts in 4's, 6's, 8's, 12's and so on. We are dealing with what look like vibration-phenomena, with their nodes and internodes; and that is just what I think they really are. Romanes, when he was studying the Medusæ, remarked that "the organism is constructed on what we may metaphysically [?] term a very definite plan"; that its organs had "a very precise geometrical relation" to one another, and that its radial canals were "disposed with perfect symmetry." These are indeed very remarkable features, and the vibration hypothesis seems fitted to account for them all.

What the motions are which the vibrations of the little bell set up in the surrounding fluid, and how these current or vortex movements may react upon the shape of the bell itself, is (I think) another chapter of the same story.—*D'Arcy W. Thompson, The University St. Andrews, in Nature.*

Oil-seed Production in Indo-China

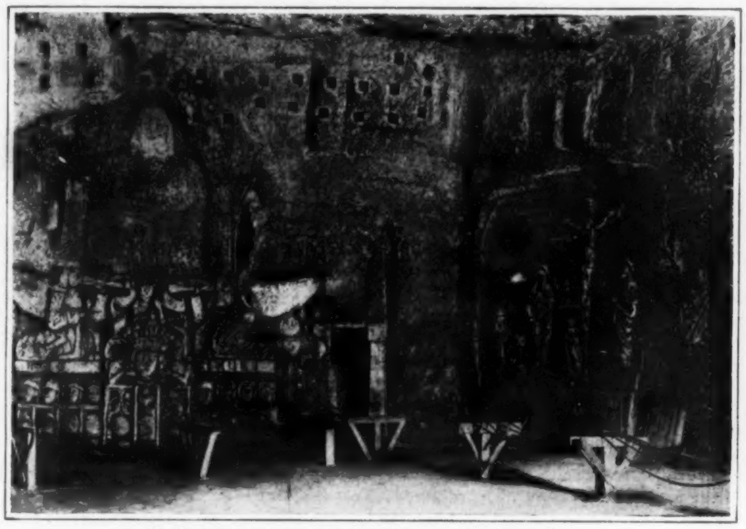
According to M. Brenier, Director of the Chamber of Commerce at Marseilles, the resources in oil seeds of Indo-China are of the greatest importance. The chief oil-bearing plants under cultivation are the cotton plant, soy bean, castor-oil plant, sesame, peanut, and coconut. The oil yield of the Cambogia soy bean is superior to that of the Manchurian, although it does not exceed 18 per cent. The castor-oil plant of Tonkin has been found to yield 42 per cent of oil in laboratory experiments, but only about 35 per cent in actual practice. Sesame cultivated in Annam and Tonkin gives as much as 50 per cent of oil. The yield per acre is 9½ cwts., as compared with 4—4½ cwts. in British India. Formerly Marseilles imported up to 420,000 tons of ground (pea) nuts annually, one-half of which came from Senegal, where a yield of 20—29 cwts. per acre was obtained. The light soils of Tonkin, Central Annam, Cochin-China, and Cambogia are more favorable, and yields up to 49 cwts. per acre have been obtained. An easily harvested type of peanut has been introduced from China, but the oil yield is not so high. The coconut palm covers nearly 25,000 acres. It is grown chiefly along the Annam coast. The coast of the Gulf of Siam, which is outside the typhoon zone, is the most favorable district for this cultivation.—*Chamber of Commerce Journal.*

Brownian Movements

After a discussion of the work carried out by various investigators the author concludes that the safe ground to take is: that the Brownian movements are due to the incessant movements of the molecules of the fluid; that the Brownian movements tend to make finely-divided, suspended particles distribute themselves uniformly throughout the liquid; that the uniform distribution is affected by the force of gravity as in the case of a gas; and that the Brownian movements, though causing diffusion, give rise to no appreciable osmotic pressure.

Very finely divided particles (less than 0.5μ, for instance) will be kept in suspension indefinitely by the Brownian movements, so long as the particles remain finely divided. If, however, two or more particles agglomerate or coalesce, the force of gravity may cause the particles to settle to the bottom of the containing vessel.—*Note in J. Soc. Chem. Ind. on an article by A. Jouscher, in Z. affentl. Chem.*

Entrance to a cave house at Chenu (Sarthe)



Sculptures cut on the walls of a grotto at Bourré

The Murman Railway

M. Goriakovsky, chief engineer of the Murman railway line, recently arrived in this country, is being quoted as heartily in accord with the enterprise of the Allied powers in their plans for intervention in the Murman Coast district. He sees the apparent enthusiasm of the Murman population for the Allied cause as an entirely consistent phenomenon, same being due to the neglect of that territory by the Bolshevist government, as a result of which it was compelled to appeal to America for relief from dearth of necessities of life and other forms of privation. He views the control of the Murman railroad as an extremely important factor in the success of the Allies in dealing with the Russian situation, or with the more immediate problem of contending with the combined Finnish and German forces reported to be working their way toward the railroad and Kola bay with the idea of wresting the line and the vast accumulation of war materials stored there from the hands of the Allies.

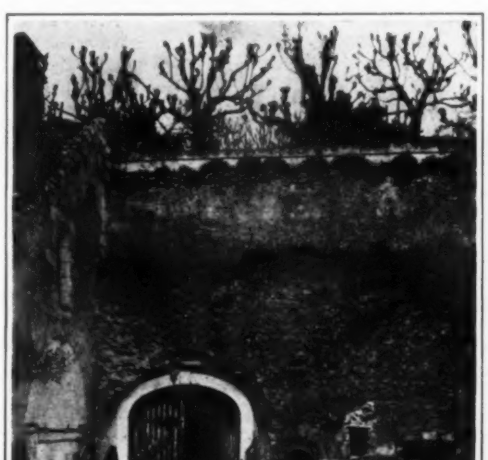
Relative to the Murman railroad, its construction and its importance as a military line, M. Goriakovsky says that it would furnish the tactical avenue of approach from the ice-free port of Murmansk and would be of inestimable value to the Allies in maintaining a steady line of communication from the Arctic to the interior of Russia. The railroad runs from Murmansk to Petrosavodsk, a distance of 1,000 kilometers, and from there connects by water with further interior points. Its distance from the Finnish border on the west varies from 200 to 60 miles. Although one-third of the route, including the harbor of Murmansk, lies completely within the polar region, the warm currents that pass through that particular region of the coast keep the port free from ice all year around and make it accessible to shipping. Russia was obliged to find such a port, because the outbreak of the war found her cut off from the sea in the south and the west, and Archangel was accessible only five months in the year, being closed with ice the other seven months.

In 1914, when M. Goriakovsky, at the direction of the Russian government, undertook to establish a permanent connection with the Allies through a harbor on the Murman coast, that part of Russia was practically virgin territory, offering all manner of engineering difficulties. The district penetrated consisted of 74,000 square miles and developed a population, including workmen, of 180,000 inhabitants. At the outset there was encountered a total absence of roads, many swamps, numerous rivers, no native labor of any account, severe climatic conditions and very limited means of obtaining food.

The necessary surveying was executed during the winter months of 1914 and 1915 in deep snow and through heavy forests. The engineers, as well as the workmen, lived in tents, and during the long polar night that obtains in that region, the surveying had to be done by the light of lamps. The actual construction began in May, 1915, and 1,000 kilometers of rail were laid through from Murmansk to Petrosavodsk by November, 1916. For Russia it was an achievement of unprecedented speed, made possible through the prompt assistance from America in the shipment of rails, equipment and materials.

Many prominent men in Russia, according to M. Goriakovsky, could not take this piece of railroad construction seriously. They thought the whole line rested upon a flimsy foundation, consisting principally of swamps and ice, and predicted that the first spring thaw would find the entire railroad line melting away and disappearing from sight. No such thing, however, happened, the road withstanding the test admirably. All swamps had been fathomed so as to obtain an exact tracing of the nature of the bottom, so that the line was laid out where the most secure foundation was offered.

Another scene at Chenu



Entrance to a cave dwelling in Champagne

Murmansk, the terminal station of the Murman railroad, is situated on the Kola gulf. It has a deep harbor, well protected against winds by the high, rocky shores of the gulf. The depth near the piers is 32 feet, and in the bay 70 feet at low tide. The tide attains a height of 11 feet at times. In the summer months there is perpetual daylight, and in the winter months the port is lighted electrically from a central power station.

The region penetrated by the Murman line is mostly covered with forests, chiefly pine trees. Near the sea there has already been considerable cutting, most of this timber being exported to England. There are some large sawmills at Soroka, Keret and Kovda. As soon as the rails on the Murman line were joined, although the line itself was not yet complete, shipment was begun to the interior of war supplies, furnished by America, England and France. During the winter of 1916–1917 the entire amount of ammunition landed at Murmansk, about 100,000 tons, was transported by the new railway from Murmansk to the front. In comparison with this achievement the transportation of munitions for the Russian army from Vladivostok by the Siberian railroad was not nearly so successful, a good deal of the materials consigned from that port never having reached the front at all. While shipments via Vladivostok rather than by way of Murmansk may be held to be safe, the distance from Vladivostok to the front is eight times greater than the distance from Murmansk. In the spring of 1917 the Murman railroad, not yet completed, carried three times as many cars to the front daily as did the Siberian railroad.

During the summer of 1917, after steamers were diverted to the Archangel harbor, the Murman railway was temporarily relieved of its traffic, and an opportunity to finish the construction of the road was offered. The erection of dams on the swamps and the ballasting of the roadbed were made possible on large scale owing to the prompt and regular delivery at Murmansk of considerable construction machinery from America. The total excavation on the Murman line amounted to 10,000,000 cubic meters, of which more than 10 per cent consisted of stone that has to be blasted out with dynamite. The combined length of the bridges on the line is 16,000 meters. At the present time, provided as it is with stations, water supplies, dwellings and materials, the Murman railway, once furnished with the necessary rolling stock, can easily carry 3,500 tons of supplies per day, while the port of Murman, with its piers, cranes and tracks, is equipped to receive the same amount of tonnage daily.—*Railway Review.*

Complex Mechanism

Excluding the engine altogether, the parts of the average biplane amount in round figures to 20,000. In the case of a seaplane the figures are more than doubled, and 44,500 is the total.

In further illustration of the multiplicity of small parts in aircraft, it may be mentioned that the split pins alone in an army aeroplane exceed a total of 2,000. This is because, in War Office machines, no burring of the ends of screw threads is permitted; the Admiralty, on the other hand, allows this method of fixing to be used in places where the attachment is never likely to be disturbed.

From the foregoing figures it is at once apparent that the assembling of an aeroplane of necessity involves a considerable degree of hand labor, to say nothing of the extreme care that is essential to the building of a machine which is nothing if not extraordinary.

Ordnance

Its Rise and Development

THE bombardment of Paris by a gun which must have an effective range of over seventy miles has given rise to much speculation as to the means by which this extraordinary result has been achieved. The matter has already been discussed with much wealth of detail, accurate and otherwise, by experts and others, but the general subject of guns is one which commands more than ordinary interest, and while but a few years ago gun-making was a branch of engineering construction known to and carried out by a comparatively few men, who were careful from both a national and a personal point of view to make a great secret of the work, at the present time thousands of men, aye and women too, are engaged in gun construction. To the old-time gunmaker this is something of a shock, for he could understand ordinary engineering establishments undertaking the manufacture of shells, or cartridges, or small-arm ammunition; he could even contemplate a locomotive shop attempting gun mountings and carriages either for naval or land service work, but guns! Yet guns are being plentifully made now all over the world in engineering works which were never intended for anything but the ordinary manufactures of peace time. It may therefore be of some interest to trace very briefly and superficially the growth of ordnance.

EARLY CANNON

Cannon were said to have been used by Edward III at Calais in 1346, and in the field at Cressy in the same year, by the Danes in 1354, and by the Venetians at the siege of Chioggia in 1366, when two pieces of artillery easily reduced the place. Gunpowder of the old-fashioned type, now commonly spoken of as black powder, was known from very remote times, and sometimes ascribed, like many other things, to the Chinese. It was described by Roger Bacon in his work, "De Mililtate Magicæ," about A. D. 1267. A German monk, Schwartz, about 1336, is said to have discovered the method of its manufacture.

There is to be seen in the Rotunda Museum, at Woolwich, one of the very earliest cannon in existence, certainty not later than the beginning of the fifteenth century. It is a wrought-iron bombard, 15.1 inches caliber, used for throwing stone-shot of almost 160 lb. weight. The chamber for the propellant charge is 3.4 in. diameter and 14 in. long, the length of the gun proper, called the "chase," is 34 in., and it weighs at present about 6 cwt. It is remarkable also for the fact that it has a liner, or interior, of cast-iron, one of the oldest specimens of cast-iron known. The bombard was found in a moat at Bodiham Castle, Kent. This gun is a muzzle-loader, yet it speaks much for the enterprise of the Ordnance Engineers of the period, when one goes a little further in the same museum and finds a breech-loader peterara of forged iron of the time of Edward IV. (1461-1480). This is made of bars of iron placed longitudinally in the direction of the bore, and hooped together with iron rings. Its length is about 3 ft. and caliber 2.5 in.

The wrought-iron cannon now in Edinburgh Castle, and known as Mons Meg, belongs to this period, and was made at Mons in Flanders (the place of the battle of imperishable memory) in the beginning of the fifteenth century. It was employed at the siege of Dumbarton Castle in 1489, and last fired in 1682, when it was partly burst. Its caliber was 20 in., length 13 ft. 6 in., and its present weight about five tons. It projected granite shot of about 330 lb. These built-up guns were rather insecure, and disasters sometimes occurred. Thus the death of King James II. of Scotland in 1460 is related by Pitscottie: "While this Prince, more curious than became him or the majesty of a King, did stand near hand the gunners when the artillery was discharged his thigh bone was dung in two with the piece of a mis-framed gun that broke in shooting, by the which he was stricken to the ground and died hastily."

It will be seen that the built-up gun, which was destined to become the standard mode of construction, was placed for some centuries under a cloud, mainly on account of the difficulties in actual manufacture, the early types being constructed of staves like a barrel, protected by hoops, while the later types were of massive hoops shrunk together, and provided with a tube for a continuous bore, the latest of all being made up of a series of tubes or elongated hoops shrunk one upon the other, bound round tightly with many turns of steel wire, enclosed in a steel case called the jacket, and provided with an internal tube. Before attempting any description of the modern type of gun, it is necessary to study the cast guns of both brass and iron which were used for several centuries after the passing of the wrought-iron gun of the earliest or barrel construction.

CAST GUNS

Guns cast in brass, or, more strictly speaking, of gun metal, were in existence in the latter part of the fifteenth century, and certainly early in the sixteenth, but the earliest dated brass gun in this country is one on the muzzle moldings of which is the name of the maker, Franciscus Arcanus, and on the first rim piece an inscription which, translated, reads: "Henry VIII., King of England and France, Defender of the Faith and Lord of Ireland, A. D. 1529." To this period also belongs the gun in Dover Castle, popularly known as Queen Elizabeth's Pocket Pistol. It was cast at Utrecht A. D. 1544, and presented by the Emperor Charles V. to Henry VIII. The inscription, which is in Dutch, is not that which is generally ascribed to this gun, and said to refer to "carrying a shot to Calais green," but literally translated runs:

Break—tear—every wall and rampart
Am I called
Across mountain and valley pierces my ball
By me stricken.

This gun is 4.75 in. caliber (a forerunner of our Long Tom of Ladysmith fame), and its length is about 23 ft.

A description of really beautiful brass guns which are to be seen in the country, but notably at Woolwich, the natural home of the artillery, would be altogether beyond the scope of this article, but it can be easily demonstrated that the ordnance engineers of practically all countries have always been craftsmen of a very high order, and frequently artists as well.

Probably one of the most handsome guns in existence is that on the Artillery-parade at Woolwich, and is know as the Bhurtpore gun. It bears several inscriptions on the chase: The Father of Victory. The Reviver of Religion. Mohammad Aurang-reb, Alam-gir, The Warrior, The Victorious King.

The date corresponds to A. D. 1677. It has several other inscriptions, such as "The gun, the aid of Ali." Ali was the hero-saint of Indian Mohammedans, whose titles were "The Victorious Lion of God," "The Remover of Difficulties." Thus, it would appear that the Kaiser himself might find a few suggestions here for his speeches and telegrams. The gun weighs 17¾ tons, with a caliber of 8 in., and a length of 16 ft. 4 in. The metal is not of uniform composition, and tradition says that it contains gold. This is not confirmed by analysis. The gun has at some time been repaired by casting other metal upon it of different composition at the breech.

"Brass" guns continued to be made in all sizes until gradually cast-iron began to replace the more expensive metal. The great gun of Ghent was said to be of 26 in. caliber, but evidently, although no great progress was made for many years, gun designers were not idle, and the germ of several of our modern fittings and details can be seen in the very early specimens. Thus, the two so-called leather guns of Gustavus Adolphus, in the Artillery Museum in Paris, and one at Woolwich, really consist of a copper tube covered with stout leather, and then bound round with a rope of spun yarn—an inspiration which may be compared with the present day practice of using flat steel wire.

Up to the middle of the nineteenth century guns were all cast in gun-metal or in cast-iron, that is, after the abandonment of the early types of built-up guns. They were used for firing round shot and shell, and were generally of smooth bore. These were the artillery of the long series of European wars ending with Waterloo, and also of our war with Russia in the Crimea. Austria was, it is believed, the last of the first-class Powers to drop the use of brass or bronze guns.

RIFLING

The introduction of the elongated projectile was accompanied by the desire to impart a spinning motion to it, and hence the principle of rifling. The cast metal, either iron or brass, was too soft to stand the wear involved in rifled guns, and it was soon found necessary to line the guns with a wrought-iron tube to take the rifling. There is, it should be stated, a record of a 3.6 in. gun which was rifled by Joseph Manton, with sixteen grooves, in 1790.

It will be observed that, with muzzle-loading ordnance, great difficulties were experienced in providing for the projectile slipping down the bore readily when loading, and for effectively checking the powder gases rushing past the shot when firing.

The lining of cast-iron guns with wrought-iron tubes was proposed by Palliser and adopted in 1863. The converted guns were sixty-four and eighty pounders. The great change in gun construction, however, came with the Armstrong system. This consisted of forming a barrel or tube of coiled iron made up to the required length by uniting short welded cylinders together, closed at the breech by a form of cup, while over all from breech to muzzle wrought-iron coils were successively shrunk to give the requisite strength transversely. This system was modified in the Fraser method, which consisted of winding coils of iron, one upom the other and finally welding them at a very high temperature into a cylinder. The guns of the sixties and for about twenty years were generally of this type, and were familiarly spoken of as Woolwich Infants, the notable cases being the 38-ton gun, 12.5 in., firing a projectile of 818 lb., with a charge of 165 lb. of black powder, having a muzzle velocity of 1,442 foot-seconds, and capable of penetrating a wrought-iron armour plate 15 in. thick at 2,000 yards, and the other the famous 80-ton gun, which fired a shot 16 in. diameter, 1,700 lb. in weight, charge of powder 450 lbs., with a muzzle velocity of 1,540 foot-seconds, and a penetration power at 2,000 yards of 22 in. of wrought-iron armor plate.

Some even larger guns were made at Elswick by Armstrong's Company, but the time for the next great change had come, and the general type of gun in use at the present time is a splendid product of engineering science.

MODERN GUNS

The old-fashioned guns were comparatively short and stumpy, very heavily built at the breech end to withstand the sudden shock of explosion of the charge of black powder. The modern gun (apart from the howitzer) is long and slender, and less heavily built proportionally, the use of cordite and other slow-burning powders rendering this extra length necessary for the full effect of the expansion of the gases to act upon the projectile, which receives a sustained thrust rather than a blow or impact on the explosion of the charge, a difference which any golfer will appreciate when he considers the value of a good "follow through" in getting a long ball.

All modern guns (trench mortars excepted) are breech-loaders, the mechanical difficulties which formerly obtained in the closing and sealing the breech being got over by an interrupted thread on the breech screw, cleverly stepped down so that the screw slips into the breech, and is secured in place by about an eighth of a turn, every thread engaging exactly, the final sealing of the gases being obtained by an obturator, a mushroom-shaped fitting furnished with a pad of compressed asbestos and tallow or oil. The wire for winding is a flattened or ribbon-shaped high carbon steel wire of great strength, and as much as a hundred miles of wire is, it is said, used for one of the great guns.

Thus the gun which plays so large a part in modern warfare is a product of the highest engineering skill, and carries accessories—for example, its sighting arrangement, which consists of a combination of optical and surveying instruments—of the highest order of refinement. The growth of the gun-mounting from the old wooden carriage or platform to the present high-class mechanism, and the progress in armor-plate construction provide chapters in engineering of a no less fascinating character.—*The London Daily Telegraph.*

German Submarine Designs

ACCORDING to information which we believe to be reliable, the German submarines which have been molesting traffic off the United States seaboard for the past few weeks, do not appear to be vessels of any remarkable size. Their displacement is reckoned to be about 1,500 tons, and they have not shown themselves capable of traveling at a greater speed than 18 knots. Whether or no they belong to the so-called "submersible cruiser" type, we have no present means of determining; but our own belief, founded on a careful analysis of all the data available, is that the largest German submarines now in existence fall very far below the popular estimate. It has still to be shown that great size is an advantage in craft designed for underwater tactics. Indeed, the experience of the war suggests the contrary. A coastal boat of 500 tons may, in most circumstances, be quite as dangerous as one of thrice her displacement. It is true, of course, that certain qualities are conferred by large dimensions, such as a longer cruising endurance, a heavier armament of torpedoes and guns, and, what is no less important, superior living quarters for officers and men. But all these qualities may be obtained at the cost of a very moderate increase in tonnage. In a boat of 1,200 to 1,500 tons, let us say, it would be possible to provide fuel for a very long voyage, good living quarters and exercise space for the complement, and a powerful armament, including, besides torpedo tubes, a couple of heavy guns. Of one thing we may be pretty sure: the Germans are not building submarines any larger than is absolutely necessary. The policy they have elected to follow demands numbers rather than individual power, and unless we are much mistaken, their aim during the war has been to evolve a type of the smallest possible dimensions consistent with the function it is intended to fulfill. We know from Admiral von Capelle that a great deal of experimentation has been going on since

1914, and that the present German submarine flotilla, so far from being homogeneous, comprises the most diverse types. In the recent debate before the Main Committee of the Reichstag, several speakers condemned the failure of the naval authorities to select some standard pattern of U-boat which would lend itself to quantity production. As one deputy complained: "Instead of taking this course, the navy-office has preferred to build submarines in small groups, with the result that new designs are continually coming before the shipbuilders, and the rate of output is thus seriously decelerated." Replying to these criticisms, Admiral von Capelle admitted that progress in building submarines had not been entirely satisfactory, and that "from time to time" the strategical plans of his department had been affected by a shortage of the necessary *matériel*. As for the "standardized submarine," it, he explained, had not been adopted for the simple reason that it was impracticable. Scarcely a week passed without some valuable suggestion being made by experienced officers for improving the efficiency of U-boats in one direction or another. "Each of our present types," he said, "embodies lessons taught by the war. A boat that is considered highly efficient today may tomorrow be rendered more or less obsolete by a new discovery. If, therefore, we built our U-boats after a uniform pattern, we should run the risk of finding ourselves saddled with a large fleet of inferior boats. In spite of the astonishing progress it has made during the war, submarine navigation is still more or less in its infancy, and its development must be by gradual stages."

Even from the published version of this debate, it is clear that German submarine construction has not been so rapid as the outside world had assumed. Delays have, no doubt, occurred through lack of structural material, though we shall do well not to exaggerate the enemy's troubles in that connection. In our view, the real source of delay has been the difficulty of hitting upon a design small and simple enough to admit of rapid multiplication, and yet capable of fulfilling every tactical requirement. We venture to doubt whether German designers place high speed among the prime desiderata. The sort of work their submarines are called upon to do does not demand great speed, to obtain which other qualities of equal, if not superior importance, must needs be sacrificed. Promptitude in submerging, for instance, is far more important; in that direction, we understand, notable progress has been made. The necessity of extending the range of his boats was forced upon the enemy by the vigilance and strength of our patrols, which made the narrow seas too dangerous a hunting ground. By building U-boats with a larger fuel capacity, he hoped to attack shipping in zones beyond the reach of the small patrol craft which form so large a section of our anti-submarine forces. Then, again, he was compelled to strengthen the armament of his submarines, in consequence of the heavier guns supplied to merchant ships. Therefore, unless a German submarine could bring equally heavy metal to bear, it would run the risk of summary destruction by the first armed merchantman it encountered. As we now know, the larger ocean-going submarines carry at least one 5.9 in. gun, an increase in armament which is their best title to inclusion in the cruiser category. Whether still heavier weapons will be found necessary remains to be seen. At the outbreak of war the largest gun mounted in enemy submarines was the 3.4 in., then came the 4.1 in., and later still the 5.9 in. This great increase in the power of submarine armament is, of course, a tribute to the effectiveness of our defensive measures. The American ideal is to equip every large merchantman with guns, which would enable her to fight a duel against any submarine afloat with a good chance of holding her own.

Reverting to the question of dimensions, one strong objection to the building of very large vessels is that their greater size does not seem to make them less vulnerable to attack. Depth charges, there is good reason to believe, are quite as deadly to large submarines as to small. If the former have armor protection, they may be better able to resist attack by guns of 4 in. and lower calibers, but it is most unlikely that they can carry armor stout enough to resist 6 in. projectiles. As for the ram and the torpedo, we know that both weapons have taken a heavy toll of the ocean-going raiders. One of the first German "submersible cruisers" was sunk recently by a British submarine on convoy duty. A single torpedo was discharged, the explosion of which, apparently, blew the hostile craft to pieces, for there were no survivors. On the whole, therefore, it is not easy to see what compensating advantage is to be gained by building submarines of very large size, and we may be sure that the Germans have not wasted their time and material in building many such vessels. One of their most successful designs, we understand, is the "UC" general service type, of which comparatively full details have been published. Upwards of sixty of these boats are stated to have been launched in 1915-16, and presumably others have been built since. The length is 170 ft., the beam 40 ft., and the displacement, when submerged, between 515 and 540 tons. On the surface a maximum speed of 15 knots can be attained, while the electric motors are good for 6 to 9 knots below water. The cruising endurance is not less than 3,000 miles. The armament is composite, consisting of one 3.4 in. Q. F. gun and a machine-gun, three 20 in. torpedo tubes, and eighteen naval mines with dropping gear. As will be seen from the particulars, these are very formidable craft, in spite of their limited size, and the fact that so many have been built shows them to have demonstrated their all-round utility. From time to time unofficial reports in the press speak of "submersible cruisers" displacing about 5,000 tons. For our part, we remain sceptical about the existence of vessels of such great size. The Germans may have built a few unusually large submarines, but for the reasons we have indicated it is most unlikely that they would have dissipated their none too extensive resources in the construction of vessels whose value is so problematical. Whenever full details of the German submarine building policy during the war come to be disclosed, we shall be surprised if it is not shown that a large majority of these craft were of comparatively limited dimensions. Probably 750 tons would be too high an average displacement for the whole German submersible fleet.—*The Engineer.*

Millions of Eggs Produced in this Country Feed No One

MILLIONS of eggs produced in this country feed no one. The natural question is, Why? And the answer is that they are carelessly handled, poorly packed in improperly constructed cases, badly stored in freight cars, or allowed to become warm on their journey from the hen's nest to the home. Prevent this enormous loss of valuable food, and loss of profits. Take every possible precaution to keep eggs fresh and wholesome, as they are when freshly laid. It is easy to get eggs to market in prime condition, says a recent publication of the United States Department of Agriculture—a circular which tells how.

The proper handling of eggs is not a one-man job, according to the circular. Many people are concerned in it. Their interests are common and mutual understanding and cooperation between them benefits all alike.

The producer's part in the general scheme of good marketing is to bring good eggs to market. To accomplish this he should market his eggs frequently—not let them accumulate.

The dealer's job is to keep the eggs good. His slogan should be "Ship promptly and properly." The sooner an egg is put under refrigeration and started for the market the better its quality when it reaches its final destination and the higher its value.

A stale egg pleases no one. Heat is the egg's enemy; cold is its friend. Precooling eggs before shipping them, therefore, saves food material. It checks the development of "blood-rings," which occur in fertile eggs subject to incubating temperature (68° F. or higher). It prevents "addled" eggs, the term applied to eggs when the membrance between the yolk and the white breaks allowing the two to become mixed. When the eggs are warm, this delicate membrane becomes soft, in which condition it is more liable to break by jars which are unavoidable in transportation. Chilling makes the eggs stiff and jellylike, and cold eggs ride best. Precooling retards evaporation, the cause of shrunken eggs. Eggs just laid are full, but 65 per cent of their contents is water. As this water evaporates the quality of the eggs is reduced. Warm temperatures aid evaporation. Precooling helps to make a uniform product, and this is a day of standardization. A weak spot in the egg trade is the lack of uniformity or standardization for its product. If each case of eggs received at the market is exactly like the last one, the shipper could establish a reputation for uniformity.

Eggs to be shipped should be well packed in clean, standard egg cases. They should be kept under refrigeration and sent to market in properly iced refrigerator cars, which retain their good quality. Refrigeration during transit maintains quality, weight, fresh appearance, and food value. It retards loss of quality, shrinkage, "blood-rings," and loss of food value.—*Weekly News-Letter of the Dept. of Agriculture.*

The Prevention and Arrest of Lice-borne Diseases

AT a meeting of the Royal Society of Medicine in July Colonel William Hunter, C.B., A.M.S., gave a lecture on the Prevention and Arrest of Lice-borne Diseases (Typhus, Relapsing, and Trench Fevers) by New Methods by Disinfection. The speaker laid special stress on the importance of trench fever. Of the medical sick in the Eastern Command 10 per cent were cases of trench fever and about another 10 to 14 per cent came from those admitted for P. U. O. Any method of disinfection must be available at all times and must be easily devised and worked. The lecturer then gave a description of two forms of disinfection which he had used on an extensive scale in Serbia, in Egypt, and in Salonika. The first was barrel disinfection, a method devised by Lieutenant-Colonel G. E. Stammers, which was very effective and very cheap. For this an ordinary wine barrel was needed (or a sanitary dustbin). One large and four or five smaller holes are bored in the bottom, and the barrel is placed on an iron boiler containing water which is heated from a fire trench, the barrel being separated a few inches from the boiler by rings or bricks. The lid is kept on tightly by a stone placed on top. The clothes are placed inside. The barrel heats in about half an hour to 100° C., and disinfection is complete an hour later. The principle on which disfection is carried out is the destructive effect on protoplasm of steam in motion. Three barrels could be heated over one fire-trench, but if this were done it was impossible to guarantee equal and efficient heating power in all three barrels. Four barrels should be sufficient for a regiment, and clothes should be disinfected every three weeks. For disinfection on a large scale (*i. e.*, masses of troops) within a short space of time he used the railway van disinfector. This was devised also by Lieutenant-Colonel Stammers, and modified by himself. For this method modified ordinary luggage vans are used. Steam from the engine is discharged backwards into the vans by means of pipes running along them longitudinally. The clothes are either hung on hooks or across bars, or done up into bundles and placed on shelves all round the van. When the doors are shut the steam is turned on. At first water is seen to drip from underneath the door, and at this time the clothes are wet. At the end of half an hour disinfection is complete, there is no drip from around the door, and the clothes are only very slightly damp, becoming quite dry about half to one minute after being shaken out. Railway van disinfection had been used extensively in Egypt, and by this method the complete kit of 8,000 men could be disinfected in four days, or 18,000 in ten days. He had made tests by placing various articles inside the van. Eggs were boiled hard in 10–15 minutes, potatoes became floury, cultures were sterilized, and a thermometer packed in the center of a large bundle of clothing registered 105° C. The initial cost of the van disinfector was £50–£60, that of the barrel disinfector a few shillings. Photographs were exhibited showing the actual disinfection of 500 Turkish prisoners, and charts were displayed illustrating the remarkable checking of the incidence of relapsing and typhus fevers in Serbia, and the lowering in the mortality rate. He considered that disinfection could be carried out by these practical measures more effectively and expeditiously and more cheaply than by any other form of disinfector at present in use.

In answer to various questions put to him by members present, Colonel Hunter said that steam in motion at any temperature over 70° C. destroyed protoplasm. No part of the scheme was devised to raise the pressure in the van, but the steam escaped from the boiler into the van at a pressure of 4–5 atmospheres. The heat of condensation and the pressure produced a temperature of 105° C. in 5–10 minutes. He had had no accidents with these disinfectors. During the time represented in the charts the conditions were of the worst description.—*The Lancet.*

Iron and Steel in China

THE possibilities of cheap iron and steel from China are well worth careful consideration. A comparison of the costs of producing a ton of pig iron in the U. S. A. and at the Manchurian works at Penchihu is very greatly in favor of the latter, owing to much cheaper, if less efficient, labor. In comparing the relative efficiency of American and Chinese workmen, it is not strictly correct to say that the production of 100 men of 50 per cent efficiency is equal to the production of 50 men of 100 per cent efficiency, for the quantity of the output may be the same, but the quality may be very different. This applies particularly to highly skilled work, but probably need not be taken into account in the production of pig iron. Before the war the freight on pig iron to the Pacific coast was about $3 (gold), and the Chinese iron could be landed at Pittsburg via the Panama Canal cheaper than the blast furnaces at Pittsburg could make it. The same may be said of steel; for the gas from the coke ovens at Penchihu can be used to convert the pig iron into steel, while the poorer gas from the blast-furnaces operates the coal mining and other machinery.—*Far Eastern Review.*

The Total Solar Eclipse of June 8, 1918

H. C. Wilson

Observations of the eclipse appear to have been very successful on the whole, in spite of the clouds which overspread much of the path of totality. The only stations reported where the sun was entirely obscured during the total phase of the eclipse were those at Denver, Colorado, and in Florida. At several places fortunate breaks in the clouds occurred just at the critical time and at others very thin clouds obscured the fainter features of the corona but permitted the brighter parts to be observed.

At Denver, unfortunately, where much was expected from the observations with the 20-inch telescope, dense clouds covered the sky all the afternoon and no glimpse was had of the eclipse. A spectrograph, especially adapted to determine the rotation of the corona had been attached to the great telescope, and the Allegheny Observatory star camera was mounted on its tube for the purpose of photographing the stars in the vicinity of the sun and testing the Einstein theory of Relativity by accurate measurements of the star places before, during, and after the eclipse. The Chamberlin Observatory, at Denver, was the only permanent observatory along the line of totality and it seems a pity that it should be the one to suffer most from clouds.

At Green River, Wyo., where the Yerkes and Mount Wilson parties were located with their fine outfit and numerous observers, clouds interfered with, but did not wholly obscure, the phenomena of totality. An independent party here seeing that a cloud was likely to cover the sun at totality leaped into a powerful automobile and raced 3½ miles to the northwest thus securing a view and photographs of the eclipse in clear sky. An account of this will be given in the October issue of *Popular Astronomy*.

At Goldendale, Wash., Baker, Ore., Rock Springs, Wyo., Matheson, Colo., and near Hartland, Kans., the weather was clear, at least during totality, and successful observations have been reported.

The writer was located at Fraser, Colo., just over the high range of mountains west of Denver, in company with Prof. F. P. Leavenworth and Mr. W. O. Beal of the University of Minnesota Observatory, and Mr. John H. Darling of Duluth, Minn. We found a good observing site on the grounds of the Araphoe Lodge, on the ranch owned by Mr. and Mrs. Wessel, who were very kind in ministering to our wants and in assisting us at the time of the eclipse. The altitude of our station was nearly 9,000 feet, and much snow could be seen on the mountain peaks in all directions around us but there was no snow at our level.

During the four days we were at Fraser the nights were beautifully clear. The mornings were clear with the exception of thin streaks of very high haze, but in the afternoons local clouds developed and small thunderstorms occurred with occasionally a little rain. On only one day was the western sky clear at the time predicted for totality of the eclipse, so that we were very dubious as to our prospects of observing the eclipse. Saturday, June 8, was the most promising in the morning, the sky being perfectly clear, but in the afternoon the usual clouds formed. They were broken summer clouds and a gap occurred just in time for an observation of the first contact, which came at 10h. 10m. 36s. Greenwich mean time—about 8 seconds early according to the time read off from the American Ephemeris Supplement map, but 4 seconds late when corrected according to the table on page 296 of the May number of *Popular Astronomy*.

Fifteen minutes before totality a large clear space opened around and west of the sun, but a black cloud to the northwest was moving straight toward the sun and our hopes were very weak that it would delay long enough for us to observe the total phase of the eclipse. However, we prepared to go through the program which we had rehearsed many times during that day and the preceding. Nearer and nearer approached the cloud and nearer came the time predicted for second contact. The bright crescent became exceedingly narrow and everything about us took on a weird look. Toward the northwest we had a clear view over a valley for thirty or forty miles, but we could not see the moon's shadow coming. That was masked somehow by the clouds. Mrs. Wessel watched for the shadow-bands but these were not seen. Suddenly a greater darkness came upon us and I thought the cloud had reached the sun. But, no! "Time!" called Mr. Darling, who was to note the moments of second and third contacts with the four-inch telescope. Mrs. Leavenworth began counting the seconds and our program for the minute and a half of totality began to be carried out. Professor Leavenworth and Mr. Beal made two exposures each with the 5-inch and 2-inch star cameras. The writer made four exposures with a two-prism slitless spectrograph. During the two long exposures of 30 seconds each, I looked up to see the corona, fearing that it would be lost in the cloud. But there it was, very brilliant, very different both in shape and color from those which I had seen in 1889 and 1900. I was surprised by the bluish white color of the corona. In 1889 and 1900 it had much more of the yellow and red in its color. This was probably due to the high altitude of Fraser, the former eclipses having been viewed from altitudes near sea level. Instead of the greater streamers of the corona being arranged east and west parallel to the ecliptic, they seemed to come from all parts of the sun's disk. The narrow polar streamers, so conspicuous in 1889 and 1900, were not noticeable. Three brilliant red prominences, about 120° apart around the limb of the moon, could be seen with the naked eye and were very conspicuous with the aid of field-glasses. "Time!" called Mr. Darling again, and totality was over. Quickly the atmosphere became brighter, but within a minute the dense cloud covered the sun again and but little could be seen of the eclipse until near the end, when the sky cleared so that last contact could be observed. This was observed by the writer, the time being noted by the other three men of the party. The three watches,

Popular Astronomy

Photograph of the Corona, June 8, 1918, by D. W. Morehouse, at Matheson, Colorado

Exposure 3 seconds between the 8th and 11th seconds of totality

when corrected by the telegraphic time signals of the four days, agreed within 1 second, giving as the time of fourth contact 12h. 26m. 40s. Greenwich mean time. This was 16 seconds early by the map time and 4 seconds early according to the corrected prediction. Unfortunately we had not arranged for anyone to note the times of second and third contacts, as all were intent on other special problems.

My exposures with the spectrograph during totality came out fairly good. The plates used were Seed's Nonhalation Ortho and yielded spectra extending from Hα to H and K and beyond. The exposure of about one-half second duration just after second contact shows about 150 lines, probably all chromospheric. The 30-second exposures during totality were much overexposed in the yellow and blue parts of the spectrum. The coronal ring, falling between the maxima of the spectrum shows very plainly on both exposures. The broadening of the lines due to the drift of the sun in 30 seconds will, however, prevent accurate measurements of position. The exposure just after third contact with an exposure of approximately a second is a little overexposed but shows from 500 to 600 lines. The coronium line is shown faintly, and will admit of a rough determination of position. A strip of continuous spectrum corresponding to the middle of the cusp runs the whole length of the plate, with no absorption lines or bands except in the ultra-violet where the image is weak.

A number of exposures made on other plates before and after totality are too much overexposed to be of any value.

Mr. Darling's account of the impression made upon him by his view through the four-inch telescope has already been published.

Prof. D. W. Morehouse has kindly sent us copies of some of his excellent photographs of the corona taken at Matheson, Colo. The accompanying illustration gives a fair reproduction of one of these. Comparison of this plate with the plate in the May number of *Popular Astronomy* will show the marked change in the form of the corona.[1]—*From Popular Astronomy*.

Isopiestic Solutions

The term isopiestic solutions which Mr. W. R. Bousfield, K.C., F.R.S., introduced at the December meeting of the Faraday Society in a paper of that title, is to designate (aqueous) solutions of salts which have the same vapor pressure (of water). The term was criticized because it is already customary to speak of equal hydrostatic pressures as isopiestic. Mr. Bousfield replied that his term referred to solutions, and it was preferable to similar terms, such as iso-osmotic, isohydric, isotonic, which all concerned aqueous solutions and the number of water molecules per molecule of salt, but were indefinite in so far as one experimenter referred to molecules of solution, and the other to molecules of solute, and chiefly because those other terms were not merely statements of facts, but were mixed up with some theoretical assumptions. Mr. Bousfield wished to correlate the number of water molecules h per molecule of solute, and when he said that aqueous solutions of potassium chloride, sodium chloride and lithium chloride were isopiestic at 18 deg. C., when $h = 12.43$, 14.23, 17.18 in the three cases, he meant that aqueous solutions of these salts, having stood for days in the same aqueous atmosphere until their vapor pressures were at equilibrium, would contain the stated numbers h of molecules of water per molecule of salt. It has not been easy to conduct these experimental determinations, he explained. He had first experimented in Torricelli vacua; this method being laborious, he had placed his solutions in various parts of a room, but had found slight temperature fluctuations too disturbing; he had also tried a slowly-turning table for his vessels. In the method finally adopted he placed four glass cylinders, 5 cm. diameter, 4 cm. deep, on a tin stand by means of which they could easily be lifted into and out of a Hempel desiccator. Each glass was furnished with a glass cover and a platinum stirrer; in the lid of the desiccator which was well ground, the joint being luted with vaseline, was a small trough, charged with water (or also a drying substance). Into each cylinder was placed a weight (2 grammes or 3 grammes) of a dry salt, the three mentioned salts KCl, NaCl, LiCl, and saltpetre KNO_3; and at intervals of about three days the glasses were reweighed to determine the loss or gain of water, the water in the trough being replenished if necessary. In this way he found that both KCl and KNO_3 took up no water in forty-six days, when NaCl had taken up 9.08 molecules and was all dissolved, and LiCl (which is known to be hygroscopic) had taken up 11.40 molecules. The h values above quoted—KCl, 12.43; NaCl, 14.23; LiCl, 17.18—were observed after eighty-five days, when the KNO_3 was still quite dry. In fact, to find values for the saltpetre, Mr. Bousfield had to proceed in the opposite way, *i. e.*, start with an aqueous solution and observe the slow drying; this line of experiments, interrupted by the war, was not yet complete. His conclusion was that for each salt without water of crystallization (such as the salts stated) there was, at a given temperature, a certain vapor pressure (critical hydration pressure) below which the dry salt surrounded by aqueous vapor would not take up water and would, if not dry, become dried. The matter is, no doubt, of practical interest for drying and concentration processes. But the method is not unassailable—we do not know which method would be—and its very delicacy suggests that the values obtained might not be of much value for the chemist working in draughty rooms with unequally-heated vessels. The discussion by Prof. A. W. Porter, Drs. J. A. Harker, R. Lessing, Greenwood and Senter, moreover, draw attention to several puzzling, though fairly well-known, features. It is very difficult to dry a wet, small filter in a vacuum or to dry a solution in a deep (not shallow) basin; when phosphorus pentoxide is used as drying agent, some particles of the agent will be found perfectly dry after months, while others have melted; Prof. F. T. Trouton found that silica and blotting paper absorbed salt from solution of sulphates, etc., up to a certain strength of the solution, but actually gave up salt to stronger solutions, and that the curve: salt absorbed and salt in solution, had two maxima, not only one maximum. All these facts show that the phenomena of the loss and absorption of moisture are very complex and proceed at a very slow rate.—*Engineering*.

Bohr's Theory of the Hydrogen Spectrum

According to Bohr's theory there are only two monatomic carriers concerned in the case of the hydrogen spectrum: the positive hydrogen ion and the hydrogen atom. The positive hydrogen ion yields, according to his theory, no spectrum, while there is a series spectrum of sharp lines corresponding to the hydrogen atom. But experiments have shown that hydrogen possesses an ultra-violet continuous spectrum, the carriers for which are monatomic, and hence Bohr's theory in its present form must be rejected. Consideration of the hydrogen canal-rays and of the time effect of a magnetic field shows that the band or many-lined spectrum of hydrogen cannot have the H_2-molecules as carriers. The existence of $^+_1$ rays of long duration and the association of a sharp spectrum with the H^+_1 ion is again not consistent with Bohr's model atom.—*Note in Sci. Absts. on an article by J. Stark in Ann. d. Physik.*

[1]See Scientific American Supplement No. 2212, May 25, 1918, p. 332.

The Significance of Glass-Making Processes to the Petrologist*

By N. L. Bowen, Geophysical Laboratory

The entry of the United States into the war was the occasion of an enormously increased demand for optical glass to be used in all kinds of military instruments. The supply of glass from abroad was almost completely cut off. In the effort to meet the demand by domestic production many problems were met with for whose solution the advice and assistance of scientific men seemed desirable. Glasses are, for the most past, silicate mixtures that have been melted at a comparatively high temperature and then cooled to the glassy state. Since the principal activity of the Goephysical Laboratory has been the study of the behavior of silicates at high temperatures, it was expected that the experience of that organization might be of material assistance, and its services were therefore called upon. I was one of the several sent to the glass plant of the Bausch and Lomb Optical Company, where we went hoping not merely to be of assistance in solving these urgent problems but expecting also to learn something of more general interest concerning the behavior of silicate liquids when handled on the comparatively large scale of the glass plant.

One of the principal requirements of optical glass is homogeneity. A fragment of glass to be used for a lens or prism must have the same refractive index and therefore the same chemical composition in all its parts, and from every pot of glass made a considerable proportion is rejected because it fails to fulfill this requirement. Naturally, the causes of inhomogeneity are diligently sought for, with the hope of removing them or reducing them to a minimum, and it may be stated that these causes are now pretty well understood. To those interested in the causes of inhomogeneity (differentiation) in masses of silicate rocks the factors that lead to inhomogenity in these artificial silicate melts are perhaps of sufficient interest to merit description.

Optical glass is made in a great many varieties with a wide range of composition. SiO_2 and B_2O_3 are the principal acidic oxides, and the alkalies with CaO, PbO, BaO, and ZnO are the principal basic oxides, though a number of other oxides enter into the composition of special glasses. The alkalies, lime, and baryta usually go into the batch in the form of carbonates; lead and zinc as oxides; and silica as quartz sand. The carefully mixed batch is usually fed in several instalments into the pots, which have already been heated to the melting temperature. Factors tending to produce inhomogeneity immediately set to work. Some constituents of the batch are readily fusible, others, especially the sand, are quite refractory. The more fusible portions quickly form a liquid which tends to filter downward through the porous structure formed by the grains of the more refractory material. This action is especially marked in the heavy glasses rich in lead.

As typically developed the result may give every appearance of liquid immiscibility and the formation of two liquid layers. The two layers may be sharply marked off from each other and may so persist throughout the run. But that we have here no true case of liquid immiscibility and that the persistence of two layers is due entirely to the slowness of diffusion is shown by the fact that appropriate stirring will completely eliminate this layering and give a single homogeneous liquid. When real immiscibility occurs in the glass pot, as it does under certain circumstances, it is quite a different matter. If the alkaline carbonates used in the batch contain a considerable amount of chloride or sulfate, these salts form a separate liquid layer which floats on top of the glass, forming the "salt water" of the glass-maker. No amount of stirring, however vigorous, will render such a mass homogeneous. This immiscibility between silicate, on the one hand, and sulfate of chloride, on the other, serves but to emphasize that immiscibility between silicate and silicate is not encountered in the whole range of glass compositions.

This process of settling down of heavy liquid through the porous mass of the batch can take place only at a stage when the mass is mostly solid. A factor tending to produce a closely related result comes into play at the stage when the mass is mostly liquid. Of all the ingredients of the batch the sand is usually the last material to dissolve. The sand grains tend to rise in the liquid and thus to render the upper parts more siliceous and of lower density. This action results in a continuous density gradient rather than in a sharp division into two layers. That it is not a spontaneous arrangement of the liquid according to the Gouy-Chaperon phenomenon is shown by the fact that as time goes on diffusion tends to lessen the gradient rather than to increase it.

Figure 1 is a photograph of a fragment of glass taken from such a pot, the straight edge being part of the original upper surface of the glass. Two parallel plane faces were cut normal to this surface and the specimen was photographed in a bright light close to a white screen. Under these conditions heavy shadows are cast by the globules of low refracting glass surrounding the silicate grains and by the tails of similar material pointing downward from them. It is obvious that silica is continually being transferred toward the top.

There can be no doubt of the correctness of this explanation of the density gradient as a result of the floating of sand grains, for fortunately the action can be interrupted and observed at an intermediate stage. When the pot is removed at such a stage and the glass is chilled, sand grains are found suspended in the glass. That they were rising slowly in the liquid and dissolving at the same time is shown by the fact that pointing downward from each grain there is a tail of glass of lower refractive index than the sourrounding glass.

In a former paper[1] I criticized the interpretation that has been offered of the result of a certain experiment by Morozewicz. The glass from his experiment showed a density and composition gradient, with the heavier portion at the bottom of the pot, and this arrangement had been explained as the result of the Gouy-Chaperon action. I offered the suggestion that the arrangement was due to differential melting with the sinking of heavy liquid at an early stage and the rising of silica grains at a later stage, though I had not at that time seen or studied the phenomenon. A careful study of the behavior of the ingredients of a galss batch leaves no question as to correctness of this interpretation. There is, then, no experimental basis for the belief in an appreciable result from the Gouy-Chaperon action in a small pot and, therefore, no present reason for assigning to it any greater importance in rock magmas than that which theory would indicate.

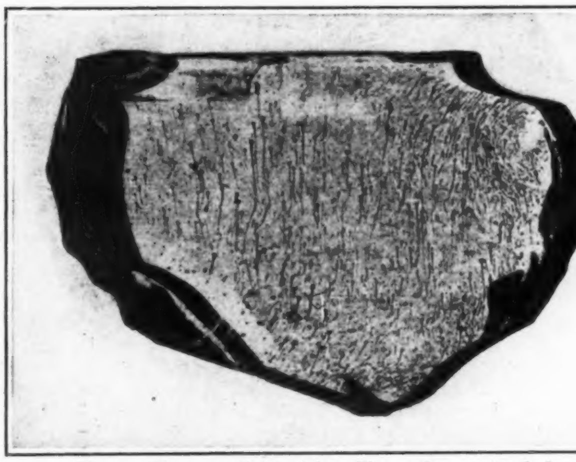


Fig. 1. Glass containing rising silica grains—natural size

There are two other factors making for inhomogeneity in glass: the solution of the pot, and volatilization of certain ingredients from the surface of the liquid. No doubt the corresponding processes, namely, solution of the surrounding rocks and escape of material into them, have their place in magmatic differentiation, but if their quantitative effect in the glass-pot is any cirterion they cannot be regarded as approaching in importance the two processes (sinking of liquid and floating of silica) that have been described above. However, the conditions are so different that one should be careful not to push the analogy too far in these cases. It may be safely stated, however, that, contrary to certain claims that have been made, glass-making processes offer no support for the belief in liquid immiscibility among silicates, nor for the belief in a significant density stratification in a mass wholly liquid. They do, however, suggest the importance of gravity acting on a mass partly liquid and partly solid, and emphasize two stages, (1) that at which there is much liquid and little solid, and (2) that at which there is little liquid and much solid. The effects of these processes in magmas—sinking of crystals at an early stage of crystallization and squeezing out of residual liquid at a late stage—have been discussed in some detail elsewhere.[2]

The association of gabbro with granite or of basalt with rhyolite, and the complete absence of intermediate types that is often noted, have been held by some to necessitate some sort of discontinuous differentiation, whereas crystallization-differentiation should, for the most part, be continuous. Evans has offered the suggestion that in aqueous magmas there may be a separation into two liquid portions, the lighter of which contains most of the water together with much silica, alumina, and the alkalies.[3] This is, of course, a possibility not altogether to be excluded, nevertheless all the available evidence is against it. Such experimental work as has been done hitherto on aqueous silicate melts gives no indication of a tendency towards a separation into two liquid layers.[4] But the range of this work is limited as yet and one must fall back largely upon examination of the geological evidence. Over against the lack of types intermediate between gabbro and granite (granophyre, micropegmatite) in some localities should be placed the abundance of intermediate types elsewhere. Again, if we examine the gabbro of a gabbro-granophyre occurrence we almost invariably find a certain amount of the granophyre occurring in the gabbro, frozen in as Daly puts it.[5] And when we examine the manner of occurrence of this frozen-in material we find nothing to lead us to believe that it represents an immiscible liquid. It does not form globular masses. large and small, scattered through the gabbro. It occupies crystallization interstices with all the marks of a crystallization residuum. Add to this the fact that it corresponds in composition with the kind of crystallization-residuum one is led to expect from experimental studies, and the reasons for appealing to liquid immiscibility may be regarded as of insignificant weight. Many petrologists regard liquid immiscibility as the ready solution of all difficulties. Realizing that present evidence is against it, some are led to "hope" that it may yet be experimentally demonstrated in silicate magmas. Until then one must regard its occurrence in silicate magmas as resting on pure assumption, an assumption that is in most cases not even helpful, and probably, never preferable to the well-supported theory of crystallization-differentiation.[6]

*From the *Journal* of the Washington Academy of Sciences, communicated by A. L. Day.

[1] The later stages of evolution of the igneous rocks. *Journ. Geol., Suppl.* to Vol. 23, p. 5. 1915.

[2] Op. cit.

[3] J. W. Evans. Discussion of paper by G. W. Tyrrell on The picrite-tes-chenite sill of Lugar. *Quart. Journ. Geol. Soc.*, 72:130. 1917.

[4] G. W. Morey and C. N. Fenner. The ternary system H_2O-K_2Si_2-SiO_2. *Journ. Am. Chem. Soc.* 39: 1173. 1917.

[5] Igneous Rocks and Their Origin, p. 241.

[6] I would be the last, however, to claim complete miscibility between sulfides and silicates. Cf. Tolman and Rogers (A study of the magmatic sulfid ore. *Standford Univ. Publ.*, 1916, p. 10).

The Zorzi System for the Electrolytic Production of Hydrogen and Oxygen

The electrolytic cells of the new system devised by Zorzi are chiefly characterized by the absence of diaphragms and by the peculiar shape of the electrodes. Each of these is formed by 16 iron bells open at the top, soldered to iron bars and equally spaced, each iron bell being covered by a glass one also open at the top. A larger glass bell covers the column so as to lead the gas into a collector pipe. The gases developed at the surfaces of the iron bells are, therefore, immediately sent through the collector pipe, so that the diffusion of a gas into the other is reduced to a minimum. The cells are made of cement, 16 cells forming a battery. The H and O collector pipes are connected to trunk collector pipes, which lead the gases to the gasometers. The electrolyte is a soda solution of density 1.17. The degree of purity of the gases obtained by the new system is very high: 1.91% of H in O and 0.34% of O in H.

Owing to their large content of electrolyte, the Zorzi cells allow of working at very different current densities without the purity of the gases being practically influenced. The new system is employed in the Nieuport-Macchi Works at Varese for oxyhydrogen and oxyacetylene soldering.—*Note in Science Abst. on an article by G. Garrara in Elettrotecnica.*

Cashew Nut Tree

The cashew nut tree of Western India yields gum, oils, medicine, dentifrice, and foodstuffs, and, of course, timber. One feature of the gum from the bark of the cashew is that it is obnoxious to insects. This edible nut is the fruit of an evergreen tree and was introduced into India from South America. It is native to South and Central America and the West Indies. The tree in its wild state is of somewhat irregular and spreading habit, but under cultivation its growth is more upright; it attains a height varying in different countries from about 16 feet to 30 feet or 40 feet. In India it grows best in sandy places, where it is often gregarious, and in South India it is important in coast-dune reclamation. —*The Engineer.*

A Review of Mycology—II*

Questions of Biology That Still Demand Study

By P. Vuillemin, Correspondent of the Institute and Member of the Faculty of Medicine at the University of Nancy

[Concluded from Scientific American Supplement No. 2230, Page 208, September 28, 1918]

The chemical composition of the chondrione is almost unknown in the vegetable kingdom. The specificity of the reactions of Benda, Meves, Regaud is compromised if it is imputed to the chrondrione to the extent of the inclusion of the basophilous grains.

Its function is no better defined. If it plays an important rôle in secretion, yet it has no monopoly thereof and does not always exercise it. "It may be admitted," says Guilliermond, "that *the majority* of the secretion products of the cell are elaborated in the heart of the mitochondria." This rôle in the animal cell is expressed by the term *aceletosomes* given to these particles by Renaud and Regaud. But we cannot refuse some capacity of elaboration to the tiniest living particle which absorb nutriment, whether it belongs to the cytoplasm or to the nucleus * * * Benda beheld in the chondiomites the assistant bearers of heredity, inert in the work of the cytoplasm; today the rôles are inverted; it is the mitochondria which labor, while the cytoplasm becomes a simple spectator of cellular nutrition.

M. Moreau[52], while he considers the secretory activity as a function proper to the chrondrione, detects no trace of it in the young portions. The mitochondrium does not begin to secrete until after a period of division. "Not every mitochondrium which divides also secretes; every mitochondrium which secretes becomes unapt to divide." In the first stage, therefore, the chondrione has no function which distinguishes it from the cytoplasm. The various forms of the chondrione depend less upon its activity (mitochondria and chondriocontia contain identical products) than on the state of growth or the repose of the cells. Moreau has proved the bipartition of small mitochondria, and he assures us that "every chondriosome proceeds from an anterior chondriosome." We record this declaration, without finding therein an analogy to the subject of the cytosomes, for, in the words of Dangeard[53] "the origin of the microsomes is involved in obscurity; the idea might be advanced that these spherules multiply by bipartition; but it is almost impossible to furnish the proof, for when the two halves of a diplococcic form become separate, it is impossible to say whether this form was not a simple association."

The critics, to begin with E. W. Schmidt,[54] have treated too lightly the opinion of Lewitzky[55], that the chondriosomes represent the progressive differentiation of the embryonic protoplasm, keeping step with the differentiation of the cells in the course of the ontogeny. Pensa[56] has followed the passage of the indistinct granules of the cellular microsomes to the mitochondria, to the moniliform, bacilliary, oval bodies, and to the chlorophyllian bodies.

The theoretic problems in connection with the question of the chondrione have not been definitely solved. These elements are recognized empirically, provided they are sufficiently voluminous, by reactions such as that of Regaud, or by their connections with the products of secretion which have not modified except secondarily the reactions proper observed at a younger stage. It is by a hazardous generalization * * * that we admit the existence of a chondrione wherever we find products of secretion similar to those whose localization has been recognized in the mitochondria or the condriocontia.

Such are the bases of the prevailing ideas concerning the chondrione in the Fungi. We will separate the investigations in which the chondrione has been recognized directly from those devoted more especially to the products of secretion.

Guilliermond brings to the fore the study of the chondrione in the green plants and in the Fungi. Since the first communication devoted to the embryo of the cereals and to the young ascus of the *Pustularia vesiculosa*[57], he has confirmed in a series of notes[58] the rôle of the mitochondria in the elaboration of the secretions of the Phanerogams: amidon, chlorophyll, anthocyanin. Moreover,[59] he has multiplied his observations in the field of Mycology; the mitochondria and the chondriocontia are followed in the basidia, the spores, the filaments, the yeasts. Meantime, Lewitzky[60] studies the chondrione in the Peronosporea, Mme. Moreau[61] in the Uredineae, Moreau[62] in the Mucorineae, Beauverie[63] in the grills and the hymenium of the cultivated mushroom and in the nycelium of the *Puccines Malvacearum*.

It is hazardous to connect with the chondrione, as does Guilliermond, a part of the basophilous grains, the metachromatic "cenospheres" of Dangeard, the vesicles of secretion, the canalicular structure of the cytoplasm of the Mortierelese. There is nothing less certain than that the corpuscles responding to Regaud's reaction are to be found in all the Fungi.

Mr. A. Meyer[64] circumscribes a group of ergastic formations, better defined than the chondrione, with the extension the botanists have given it. The allinants—this is the name he gives them—are to be recognized by a series of microchemical reactions characteristic of the chemical group of the allines: fixation without contraction by formol, osmic acid, 3% nitric acid, fixation and coloration by picric acid on the iodo—iodurated solution, fixation with deformation by boiling water, alcohol, and sublimate; they are soluble in 2% potash as well as in Javel water; 40% pepsin does not attack them; 20% trypsin attacks the allinants much more slowly than the cellular nucleus. Meyer does not pronounce upon the presence of the allinants in the animal cells; but he declares that they are often described among plants under the name of chondriosomes and mitochondria. The trophoplasts are categorically separate from the allinants; the author insists that a trophoplast never proceeds from an allinant; he accuses of error the authors who see in the plasts a derivative of the chondrione, at least in the cases in which the allinants have been misleadingly described as parts of the chondrione.

The allinants are, according to Meyer, reserve materials composed of ferronucleins; by the designation ergastic formations, he understands therefore, elaborated products without concerning himself with the agent of this elaboration; the ergastoplasm of Bovin, on the contrary, is the workman considered independently of his work; this active sense is discarded by Meyer, even for the chondriosomes of animals, which he considers ergastic formations also, without positively assimilating them to the allinants.

As in researches on volutine Meyer gives us means of discerning certain portions of the cell by microchemical reactions; but he neglects to elucidate their relations of position and of origin with the parts previously distinguished, cytoplasm or secreting plasts; while he emphasizes the gaps in the theory of the chondrione he does not indicate the means of filling them.

B.—*Metachromatine and other Products of Secretion.* The secretion products easiest to localize by histologic processes are the liquids or solids, plentifully enough accumulated to appear directly or by the aid of colorants. First to be accepted was the localization of liquids, of substances held in solution, such as glycogen, oils, etc., in the vacuoles, that of the solids in the plasts or leucites differentiated or kept in the simple state of the chondrione. The plasts, long unrecognized in the Fungi, are abundantly represented therein by the mitochondria and the chondriocontia; this explains to us the intimate connection between the studies of mycologists upon the chondrione and those upon the products of secretion.

Attention has been specially concentrated upon the metachromatic corpuscles, which are provisorily confused with the grains of volutine, because, in default of chemical analysis, they are recognized by a simple coloring reaction. Upon the relations of the metachromatic corpuscles to the chondrione cytologists hold diverse opinions. Some see therein only secreted products; others seem to confound them with the secreting organ. Guilliermond[65] adopts a middle view. In the cells of the pseudo-parenchyma of *Pustularia vesiculosa* he preceives all the forms of transition between the chondriocontia and the metachromatic corpuscles; vesicles escaped from the chondriocontia with a thin mitochondrial skin are mingled with more advanced states in which this skin is interrupted, reduced to a cap, then entirely disappears, leaving the metachromatic corpuscle naked. In the *Pesiza leucomelas* we may observe the transformation of a part of the chondriocontia with large grains, compared by the author to the basophilous grains of Maire and to the cenospheres of Dangeard.

In the same note Guilliermond expresses the belief that golubles of fat and of glycogen are formed inside the chondriocontia; but he admits that his observations have not informed him upon this point.

According to this the metachrometic corpuscles, the basophilous grains, etc., would be portions of the chondrione transformed by the effects of their secretory activity. It will be admitted that they differ as much from the chondriosomes as do those from the cytosomes.

Before taking part in the debate roused by the discovery of the chondrione which *transforms Cytology;* Guilliermond had described the metachromatic corpuscles in the interior of the vacuoles; he had proved that in the yeasts the nuclear vacuole of Wager is a vacuole of metachromatic bodies. H. Penau[66] had confirmed these results for the *Endomyces albicans.* We have just seen how Guilliermond places in the chondrione the origin of the corpuscles which have migrated into the vacuoles.

Dangeard's evolution of ideas has followed an inverse direction. Convinced at first that the metachromatic elements, like the grains of starch, are always born in the interior of, and at the expense of the leucites (mitochondria or chromatosphores), he now maintains[67] that the metachromatic corpuscles, at least in the Fungi and the Algae, are a modification of the juice of the vacuoles. The metachromatine appears in the state of a colloidal solution; the corpuscular form results from the abstraction of liquid, either by progressive natural evaporation or by precipitation by means of reagents. The spherules, the rods, the flexible funicula, the networks, which present the reactions of metachromatine in the Mucorineae, are molds of the vacuoles whose form takes that of their condensed contents.

The rôle of the metachromatine is no less obscure than its chemical composition, its origin and its localization. In the beginning Guilliermond and Beauverie presented it as a reserve substance. E. Foex[68] regards it, in the Erysiphaceae, as a transitory reserve giving place to another reserve material contained in the fibrous bodies of Zopf. M. and Mme. Moreau[69] find it indifferently among the most diverse fungi, in elements in process of active growth and in the completely quiescent spores. Beauverie[70] insists upon the persistence of metachromatic corpuscles in old cultures of *Botrytis cinera*, in the fungi which produce rust in cereals, in the mychorhizes of orchids and upon their survival in filaments which are dead or digested.

The obscurities which surround the question of the matachromatic corpuscles can but be aggravated by their association with those which obscure the subject of the chondrione. Dangeard[71] therefore, is inclined to dissociate the two problems. Since the metachromatic elements, not only among the Mucorinea but also among the Mucedineae, the Ascomycetes, etc., "have the appearance, the dimensions and certain of the characteristic properties ascribed to the chondriosomes, it is natural to think that they have been frequently described as mitochondria and chondriocontia, especially among the fungi; if the two systems are really different it will be proper henceforth to distinguish them precisely and to show how they are superposed."

Meanwhile there is no necessity for discrediting equally the opinions of Guilliermond and of Dangeard. Ideas pass; facts remain. At the time when the doctrine of the chondrione had not yet transformed Cytology, it was believed that the cytoplasm was the chief artisan

*Revue Generale des Sciences (Paris).

[52]C. R. Soc. Biol. vol. LXXVIII, 1915 (obvious misprint corrected).

[53]Bull. Soc. Mycol., France, vol. XXXII, p. 44: 1916.

[54]Vegetable Mitrochondria. Progressus rei botanicae (*Botanical Progress*), vol. IV, 2, 1912, and *Zeitschr. Bot.*, vol. IV, 1912.

[55]*Berichte deutsch. botan. Ges.*, vol. XXVIII, 1910.

[56]*Anat. Ans.*, vol. XXXIX, 1911.

[57]*C. R. Ac. Sc.*, vol. CLIII, 1911.

[58]*C. R. Soc. Biol.*, vols LXXII and LXXXIII, 1912; LXXVI (sic) 1914.—*C. R. Ac. Sc.*, vol. CLVII, 1913; vol. CLXIV, 1917.

[59]*C. R. Ac. Sc.*, vols. CLVI and CLVII, 1913.—*C. R. Soc. Biol.* vols. LXXIV and LXXV, 1913—*Anat. Anz.*, vol. XLIV, 1913 and, XLIV, 1914.—*Rev. Gen. Bot.*, vol. XXV bis and vol. XXVI, 1914. —*Ber. deutsch, Bot. Ges.*, vol. XXXII, 1914.

[60]*Ber. deutsch, Bot. Ges.*, vol. XXXI, 1913.

[61]*C. R. Soc. Biol.*, vol. LXXVI, 1914.

[62]Researches on the reproduction of the Mucorineal and some other Thallphytes. Thesis, Paris, 1913.

[63]*C. R. Acad. Sciences*, vol. CLVIII, 1914.

[64]*Ber. deutsch, Bot. Ges.*, vol. XXXIV, 1916

[65]*C. R. Ac. Sc.*, vol. CVII, July 7, 1913.

[66]*Revue Generale of Botany*, vol. XXIV, 1912.

[67]*Bul. Soc. Mycol.*, France, vol. XXXII, pp. 27 and 42, 1916.

[68]*C. R. Ac. Sc.*, vol. CLV, 1912.

[69]*Bul. Soc. Mycol.*, France, vol. XXIX, 1913.

[70]*C. R. Soc. Biol.*, vol. LXXV, 1913.

[71]*Loc. Cit.*, p. 48.

of nutrition. The secretory function was supposed to devolve particularly upon the plasts or leucites, among which there was no categorical separation of those which were distended by a liquid; the vacuoles were hydroleucites for Van Tieghem, tonoplasts for De Vries. Since liquid crystals are known to exist, colliodal solutions passing into the compact or pasty state upon diminution of the intermicellery fluid, we have less right than ever to establish a demarcation between the plasts which secrete liquids and those which secrete solids, between the vacuoles, the leucites, and the various elements attributed to the chondrione.

The localization of the crystelloids has roused as many vain controversies as that of the metachromatic corpuscles. According to Moreau[72] the crystalloids of mucorine have their birth and growth within the granulous mitochondria. B. Nemec[73] reproached Tischler[74] with having taken for the mitochondria, long trains of proteic crystelloids situated in the galls produced on roots by the *Heterodera*. There has been no attempt as yet to introduce the chondrione into the nuclei, whether of plant or animal, with which various authorities have described proteic crystalloids.

We will say as much for the oleaginous substances. While Guilliermond is inclined *a priori* to connect them with the products of the chondrione, Dangeard,[75] declares that, in the Mucorineae, they are born in the cytoplasm; this same origin has appeared to him to be a general character in both the Fungi and the Algae.

To return to the metachromatine, whether at first it is solid or dissolved, it appears in a cavity limited by solid protoplasm; Dangeard regards this as a vacuole; Guilliermond considers it a vesicle of secretion excavated in the elements of the chondrione in proportion as it assumes the characteristics of the metachromatic corpuscle. Moreau[76] observes, in the tubercles of the *Verticillium Lactarii*, metachromatic corpuscles which are at first compact, then transformed into a vacuole by the invasion of a liquid which crowds the solid metachromatine toward the periphery. Let us lay aside the chondrione, very well known in animal histology, but prematurely exploited as a means of solving the difficulties of the cytology of the Fungi. Let us return provisorily to the compact or vesiculous plasts, and the contradictory opinions of mycologists will be readily reconciled.

Second Part: Symbiosis

The existence of Fungi is intermingled with that of animals, Algae and the higher plants in a union more or less close, which does not, however, necessarily involve the annoying consequences which commonly attach to parasitions. The economic interest of the results of this common life, or symbiosis, have not engaged the attention of biologists to the point of distracting them from the fundamental problem of the nature of the connections established between two different creatures.

I. RELATIONS OF FUNGI WITH ANIMALS

The relations of Fungi with insects have long occupied the minds of the masters of Entomology such as Borg de Saint-Vincent and Giard. Biers[77] remarks upon the perspicacity displayed by Henri Fabre in his mycological observations as well as in his celebrated researches upon the habits of insects. It is the broad view of minds free from the narrow bounds of a single chapter of natural history which has enabled us to comprehend all the degrees of intimacy which exist between Fungi and animals.

Pursuing the researches of Sulc and Pierantoni, G. Teodoro[78] shows the relation between the *Saccharomyces apiculatus* var. *parasiticus*, of the free yeasts in the hemolymph of several phytophages and the *Lecaneum oleae*, *L. hesperidum*, *Pulvinaria catenicola*, *P. vitas*, especially the females. Peklo[79] considers the mycetocytes of a Flea of the Plane to be colonies of the *Azotobacter Woodstownii*. P. Buchner[80] devotes three memoirs to the problem of the mycetocytes Hemiptera. The fusiform or vesiculous globules upon which are founded the provisory genera *coccidomyces* and *Drepanosiphon* occupy either the adipose body, or a flattened uneven organ, or an organ with three strata provided with oxygen by trachea. The female transmits the Fungus to the egg, or, if it is viviparous to the larva at the beginning of gestation. In the Coleoptera Buchner verifies the migration of the Fungi of the middle intestine toward the follicles and the eggs; the symbiosis is profound, permanent and hereditary. He attributes to Fungi an important rôle in the nutrition of the consortium; with Peklo he thinks of the possibility of a capture of nitrogen from the air.

P. Portier[81] believes the symbiotes to be indispensable to the existence of their hosts. He describes the commensured forms often housed in the cells of the *Nonagria typhae* in the egg, the caterpillar, the chrysalis or the butterfly; these are isolated or unmated cells recalling the preceding descriptions; but Portier thinks them conidia. The cultures have furnished him with forms recalling the Micrococci and the filaments from which are detached fusiform conidia which are either isolated or united into fragile chaplets. We have not grasped wherein these cultures recall a typical *Isaria* and we dare not believe with the author that the *Isaria* which destroy insects habitually exist in a special commensal state.

Insects carry the spores of Fungi as well as the pollen of the Phanerogams. These superficial and originally accidental relations become more intimate when the associates find a common *terrain*, especially a plant, to exploit. Heald and Wollcott[82] have observed in America a rotting of the flowers of the carnation caused by the *Sporotrichum Poae* associated with the *Pediculopsis graminium*. As their name indicates these parasites are frequent upon cereals, which they attack separately; only the second was noted in Germany. Molz and Morgenthaler[83] received from Thuringia in 1912 carnations invaded by the same consotrium, the mites carry the spores and even fragments of the mycelium of the fungus; in return they find a choice food in the products decomposed by the *Sporotrichum*, either in the petals of the flower or in nutritious gelatine.

The same connivance is asserted by H. Schmidt[84] between the lice and the *Albugo candida*. The Peronosporeae deform the inflorescence of the Cruciferae, which take on the aspect of candelabra with a piling up of the flowers at the apex; these succulent organs are the chosen spot of lice. In the same way the *Aphis rumicis* forms hard phalanges on sorrel shoots invaded by a fungus. Schmidt always finds the cushions of the *Melampsora* under the leaves of the *Salixtriandra* whose male catkins are deformed by the *Rhabdophaga heterobia;* these cohabitants inhabiting different stages doubtless have points of contact which remain to be determined.

The Ant Fungus-raisers are well known—not only sowing fungi occasionally, but putting their cuttings in orderly piles to feed upon them. It would be puerile to ascribe an agronomic intention to the insects; but the fact remains; they profit by the fungus as man profits by wheat. Termites cultivate fungi in the same way. In all the Termite hills of the orient T. Petch[85] found the same conidiosporous mould, the *Aegerita Duthei*, associated with large fungi belonging to the genera *Collybia*, *Podaxon*, *Xylaria*, *Peziza*, *Neoskofitzia*.

The consortium is complicated when the ants establish themselves along with their crops[86] in the organs of the higher plants. H. Mieha has completed our knowledge of the ant plants of Java. The tubercles are traversed by passages constantly inhabited by the *Iridormyrmex*. It is believed that in exchange for shelter the ants protect the tree against ravages. Miehe established the fact that they feed on fungi which probably follow in their train. The wall of the passages sends out warts which draw water; *Cladosporium* planted upon these suckers is regularly reaped by the ants, whose dejacta provides the required fertilizer.

The *Crematogaster* of East Africa produces galls in which are collected fragments of *Acacia* leaves. In one of these galls Le Cerf[87] found a Lycenide caterpillar which had certainly grown larger therein, since its size was disproportional to that of the orifice. This phytophagous larva is tolerated by the ants which are probably indebted to it for extra fertilizer for their fungi.

In speaking of the Myxomycetes of the Amoeba we are not quitting the animal kindgom. The *Spicaria Fuligonis Moreau*[88] is described by its author as a parasite of the *Fuligo septica;* we believe that it develops upon the ripe sporangeium of the Myxomycetes as upon an inert organic medium. Mlle. Jaworonkowa[89] has proved that the *Ramularia myxophaga* prevents the germination of the spores of *Didymium difforme*.

M. and Mme. Moreau[90] have studied the triple association of a lichen, *Peltigera polydactyla*, of an Ascomycete, *Agyrium flavescens* and of an Amoeba, *Amoeba, Sphoeronucleolus*. The filaments of the fungus inserting themselves between the medullary elements of the lichen coil themselves up, then form receptacles protected by the mortified tissues of the host. The Amoeba which habitually lives in the shelter of the lichen without injuring it, preys upon the more delicate fungus; it seems to defend its hearthstone as the garrison of the myrmecophilous plants.

II.—RELATIONS OF FUNGI WITH ALGAE, LICHENS, AND MUSCINEAE

The lichens, the classic example of the symbiosis between an alga and a fungus, are found upon the coriaceous fungi as well as upon tree trunks or stones. One is always doubtful of the promiscuity of algae and fungi fortuitously assembled upon the touchwoods. Miss Lorrain Smith[91] reports upon a fungus which she calls *Xylobotryum caespitosum*, the supposed lichen described previously by Philipps under the name of *Sphinctrina caespitosa*.

Fungi which are parasites upon lichens are more frequent. The Abbe L. Vouaux[92] has just constructed the vast synopsis thereof; this masterly work roused hopes of valuable complements, but the author has died for the honor of France.

According to earlier experiments of G. Bonnier, the protonemae of moss are capable of forming with fungi a consortium analagous to the lichen. Mme. Tobler-Wolff[93] defines the characters of the *Synchytrium pyriforme* which forms galls on the *Anomodon viticulosus*. The *Cladosporium epibryum* collected in Canada and in Bolivia upon eight species of mosses by E. G. Britton[94] is scarcely a parasite. Quite superficial is the epiphytism of the *Bryum capillare* var. *meridonale*, found by G. Zodda[95] on the cap of a Polyporea living on the stalk of the filbert.

R. Timm[96] notes at Kullen, in Sweden, twelve hepaticas and thirty-seven mosses accidentally associated with lichens.

III. RELATIONS OF FUNGI WITH THE UNDERGROUND PORTIONS OF PHANEROGAMS

The association of a fungus and a root in a mycorhize is not as well balanced a consortium as the association of a fungus and an alga in a lichen; the greatest advantage is now for the fungus, and now for the superior plant; but it will be wrong to generalize and compare the fungus either to a simple parasite or to a simple prey; the advantage often alternates between the assoc[illegible] tingu[illegible] cover[illegible] filaments penetrate [illegible] tions do not exclude each other. It must be understood that ectotrophic mycorhizes are those in which the union is not very intimate or is of short duration.

The cryptogamic portions of mycorhizes are generally sterile and indeterminable. To connect them with classified species we must resort to analysis by separating the fungus from the root and cultivating it, or to synthesis by reconstituting the mycorhizes by bringing into relation with the fungi plants which have been cultivated since germination under protection from germs. This synthesis has not been achieved with various molds obtained by planting nutritive mediums with fragments of the mycorhizes of trees.

The most recent researches permit us to believe that the large fungi are the habitual agents of the extrotrophic mycorhizes.

J. Fuchs[97], having vainly tried to reconstitute mycorhizes with the aid of molds proceeding from mycorhizes, has tested various Basidiomycetes growing near the trees attacked; he obtained a demonstrative result by introducing pure cultures of *Collybia macroura* in young plantations of Weymouth Pine obtained in sterilized humus.

W. B. MacDougall[98] attributes the ectotrophic mycorhizes of the American linden to a Russula, those of the birch, now to the *Boletus scaber* var. *fuscus*, now to a Cortinarius, those of the white oak to the *Scleroderma vulgare*.

B. Peyronel[99] in a minute investigation of the distribution of hooded fungi in the forests near Riclaretto in Piedmont also found Russulae at the foot of lindens, the *Boletus scaber* in the company of the birch. Other species it is true accompany these essentially forest

[72] *C. R. Soc. Biol.*, vol. LXXVIII, 1915.
[73] The Problem of Fecundation Processes. Berlin, 1911.
[74] *Jahrb. Wiss. Bot.*, vol. XLII, 1906 (Annual of Botan. Science).
[75] *Loc. Cit.*
[76] *Bull. Soc. Bot.*, France. vol. LXXI, 1914.
[77] *Bul. Soc. Mycol.*, France, vol. XXVIII, 1912.
[78] *Atti Acc. Veneto-Trentino-Istriana*, series 3, vol. V, Padua, 1912.
[79] *Ber. deutsch. Bac. Ges.*, vol. XXX, 1912.
[80] *Sitzungsber. Ges. Morph. u. Physiol.*, Muenchen (Minutes of Society of Morphology and Physiology, Munich) vol. XXVII, 1912—ibid vol. XXVIIII, 1913—*Naturw. Wochenschr.*, vol. XII, 1913.

[81] Pgysiological Researches on the Entomophytous Fungi, Paris, Jacques Lechevalier, 1911.
[82] *The Nebraska Experimental Station*, vol. XX, 1907.
[83] *Ber. deutsch. Bot. Ges.*, vol. XXX, 1912.
[84] *Fuhlings, landw. Zeit.*, vol. LXIII, 1914.
[85] *Ann. Roy. Bot. Garden Peradeniya*, vol. V, 1913.
[86] *Abhandl. K. Saechs. Ak. Wiss.* (Report Royal Academy of Science of Saxony), vol. XXXII, 1911.
[87] *C. R. Ac. Sc.*, vol. LVIII, 1914.
[88] *Bul. Soc. Mycol.*, France, vol. XXXII, 1916.
[89] *Bul. Soc. Mycol.*, France, vol. XXX, 1914.
[90] *Bul. Soc. Mycol.*, France, vol. XXXII, 1916.

[91] *Trans. Brit. Mycol. Soc.*, vol. III, 1911.
[92] *Bul. Soc. Mycol.*, France, vols. XXVIII-XXX, 1912-1914.
[93] *Ber. deutsch. Bot. Ges.*, vol. XXX, 1912.
[94] *The Bryologist*, vol. XIV, 1911.
[95] *Bul. Soc. Bot. Italian*, 1912.
[96] *Verh. Naturw. Ver. Hamburg*, third series, vol. XXI, 1913.
[97] *Bibl. Botanica*, vol. LXXVI, 1911.
[98] *Am. Jour. Bot.*, vol. I, 1914.
[99] *Rendic. Accad. Lincei*, fifth series, vol. XXVI, March 4, 1917.

growths. The mycological flora of forests of larches is rich in Boleta, three species of which are proper to them: the *boletus elegans, B. laricinus, Boletinus Cavipes*. The *Boletus elegans* is found in deciduous forests with sporadic larches; but it is not always under the cover of the larch; the humus which nourishes it contains neither the debris nor the needles of this tree; this fact restricts the problems of the commensalism of the larch and the *boletus elegans* to the relations between the underground parts of each. An indirect influence of products excreted by the roots not being very probable, the most plausible hypothesis is the direct association of the mycelium with the ramifications of the root. Pyronel sums up his observations in these words: "The ligenous growths under which the hooded fungi abound are precisely those which possess ectotrophic mycorhizes; the growths lacking Hymenomycetes either possess endotrophic mycorhizes or none at all."

MacDougall sees in the ectotrophic mycorhizes a fugaceous and superficial association, in the Hymenocete an accidental parasite whose development at the surface of the roots is annual. Ceillier[100] regards the fungi as parasites nearly indifferent to the adult plant; on the other hand the mycorhizes are favorable to the early development of the seedling.

We will not undertake to establish a barrier between the two classes of mycorhizes nor limit too hastily the rôle of the large fungi in the formation of superficial coverings. The researches of S. Kusano[101] indicate how inexact such exclusion would be. The *Armillariella mellea*, capable of killing large trees and debarking them by means of mycelian funicles and webs, called *Rhizomorpha subterranea*, finds its master in the matter of parasitism in an orchid which is lacking in chlorophyll, the *Gastrodia clata*. The fungus attacks the orchid after the manner of a parasite; branches starting from the rhizomorph penetrate like suckers into the cortical layers of the tuberculous rhizome constituting the entire vegetative apparatus; the membranes of the compressed cells are partially dissolved. Thus far the association between the Basidiomycetes and the rhizome recalls pretty nearly that of the ectotrophic mycorhizes with aggravation of the damage caused by the fungus. The filaments penetrate subsequently into the interior of the sub-cortical cells; parallel modifications of the cellular content and of the invader follow, both within and without. In the first zone, both cells and filaments are of normal aspect; in the second the fungus is in irregular heaps; in the third the highly excited cellular activity is revealed in the nucleus by hyperchromatism, hypertrophy, deformations, constrictions, and in the cytoplasm by opacity, the accumulated granulations about the filaments which, little by little, disappear; at the same time the anylaceous reserves are digested and reabsorbed; in a word, the fungus becomes the prey of the cells whose vitality it has super-excited. Afterwards the cells, nucleus, cytoplasm and reserves resume their normal aspect. In the relations of the *Armillariella mellea* with the *Gastrodia* studied by Kusano, the association is alternately profitable to the Basidiomycete, to the two associates, and finally to the orchid.

The profits and losses of each associate undergo the same vicissitudes in the true mycorhizes in which the endotrophic type predominates. We find an example of this in the studies by Peklo[102] on the mycorhizes of Pines and Firs, completing his previous researches on the Beeches. The apex of the root is at first hooded with a mycelian cap; the filaments which insinuate themselves into the meatus are excluded from the cells rich in tannin, but invade the elements gorged with starch of the vegetative apex and of the zone of growth; surfeited, they are in their turn digested and augment the vigor of the vegetative apex.

In contrast to this first type Peklo notes another in which the Pine does not recover its losses, and in which the endotrophic infection is revealed by annual strangulations of the root.

In forest soils rich in humus the dominant type is that in which the superficial covering is much reduced, while the fungus renews itself with so much the more vigor since it sends a larger number of its filaments to feed upon the cells of the root.

Peklo has studied the subject of the gain in nitrogen generally attributed to the mycorhizes. Möller having combated the view of P. E. Müller asserting the fungus to be a fixator of the nitrogen of the air, Peklo cultivated the moulds obtained by transplanting minute fragments of the mycorhizes of conifers in nutritious mediums; every harvest obtained showed an excess of nitrogen over the quantity introduced; the benefit is slight, but it is not necessarily so restricted in natural conditions in which the production finds new outlets. The most serious objections is that it has not been proved that Peklo's moulds proceeded from the mycorhizian symbiosis.

[100] Researches upon the Role of the Mycorhizes and the Factors of their Distribution, Thesis, Paris, 1912.

[101] *Annals Botany*, vol. XXV, 1911.—*Jour. Coll. Agric. Imp. Univ.*, Tokio, vol. IV, 1911.

[102] *Sitzungsber. Gaerungsphysical* (Minutes on Physiology of Fermentation), vol. II, 1913.

Weyland[103] has shown the abundance of urea in the tissues of plants provided with endotrophic mycorhizes, such as the orchids and the *Polygala*, and its disappearance in two days in plants freshly cut immediately above the level of the root, then placed either in water or in a dilute solution of dextrose; the urea continually introduced by the mycorhizes is therefore assimilated by the aerial shoots. This experiment does not prove that the urea is produced by the fungus rather than by the root. Without doubt urea has been observed in various fungi, especially the Coprinae; but Weyland himself, however convinced he may be of its rarity in the autotrophs, has found it in a fern and in a horse-tail growing in a soil rich in humus. Fosse[104] mentions urea and urease both in the *Sterigmatocystis nigra* and in the seedlings of the *pea* and of the *soy bean*, which possess, it is true, symbiotic tubercles. It is necessary to go beyond urea to explain the role of the fungus of mycorhizes in the nitrogenous alimentation of the higher plants. The only incontestable point is that the fungus enables its associate to participate in saprositic nutrition.

IV. RELATIONS OF FUNGI WITH AERIAL PARTS OF PHANEROGAMS

The "witches' brooms," long regarded as parasitic deformations, are symbiotic associations of reciprocal or alternating mutual benefit; what the mycorhizes are to the root, these are to the aerial shoot.

The witches' brooms of the cherry contain enough green leaves to supply them with the needed carbon nutrition without assistance from the unattacked branches. Heinricher[105], having grafted a shrub with four branches invaded by the *Exoascus*, obtained in five years a top completely subjected to the parasite; the terminal bud died early; the leaves of the "broom" were provided with a normal apparatus of assimilation and produced starch, except in those portions deprived of light by the application of opaque bands.

A large "broom" observed on a Swiss larch by Jaccard[106] manifested its superiority to the unattacked shoots in the presence of predatory foes; it alone escaped the voracity of the *Tortrix pinicolata* which had stripped the rest of the tree; the tuft invaded by the fungus was covered with cones from the topmost twig clear down to the trunk formed by the union of seven great branches. The spring wood was much ahead of the autumn wood. This fact agrees with the habitual precocity of witches' brooms.

The winter sleep is not so profound in the "brooms" as in unattacked shoots. According to Schellenberg[107] it is imposed upon the witches' brooms of the cherry, fir and birch by the arresting of the ascension of water in the healthy branches; but the fungus maintains an extra-normal degree of activity in the invaded branches. An experiment of Schellenberg brings out this difference: "broom" branches and healthy branches were cut during the winter and placed in identical positions. The renewal of vegatation was accelerated 18 to 20 days in November and 4 to 6 days in February in favor of the former. The lesser degree of maturity or of insensibility provoked by the common life renders the witches' brooms less resistant to frost.

R. Maire[108] gives the name of false witches' broome to the tufts of arbutus shoots invaded by the *Exobasidium Unedonis* n. sp. These shoots have no unusual ones among their number and are not branched like those which constitute witches' brooms; they merely show the same deformation and the same precocity. In the forests of Algeria tufts of a pale reddish green unfold in February and die before the healthy shoots have attained their definite dimensions.

Whether true or false, witches' brooms pertain to perennial plants upon which they partially replace the aerial vegetation. In perennials whose underground portions alone survive during the winter the aerial shoots totally invaded are comparable to false witches' brooms. I have pointed out elsewhere the precocity of shoots of *Euphorbia Cyparissias* deformed by *Uromyces Pisi*. Tischler[109] recognized in the structure of their leaves means of resisting desiccation. The thin cuticle, the numerous stigmata, the surface larger than in normal leaves, are favorable to transpiration; on the other hand, the supply of water is lessened by the mycelium which obstructs the vessels of the young shoots; moreover the high osmotic tension resulting from the accumulation of sugars in the cells of the foliary parenchyma restricts the loss of water. The shoots associated with the fungus present a Xerophilous adaptation.

[103] *Jahrb. wiss. Bot.*, vol. LI, 1912.

[104] *C. R. Ac. Soc.*, vol. CLVIII, 1914.

[105] *Ber. deutsch, Bot. Ges.*, vol. XXXIII, 1915.

[106] *Landw. Land-u.-Forstw.*, vol. XII, 1914.

[107] *Ber. deutsch, Bot. Ges.*, vol. XXXIII, 1915.

[108] *Bull. Station Rech. forest du Nord de l'Afrique*, vol. I, 1916.

[109] *Flora*, vol. CIV, 1911.

In one of his latest works Potonié[110] arrives at an inverse conclusion as to the shoots of Andromeda invaded by the *Exobasidium Andromedae* and analogous to the false witches' brooms of Maire; he believes that the flattening of the parasite ridden leaves corrects the xerophilous adaptation of the normal leaves. This opinion is based upon superficial observation, which would doubtless be corrected by so precise an analysis as that of Tischler. The interpretation of Potonié is falsified by a preconceived idea; he would fain find in the parasite deformations an awakening of latent atavistic tendencies. The preceding example is not more convincing than another derived from the development of stamens in the female flowers of *Melandryum album* under the influence of the *Ustilago Antherarum*, for the rudiments of stamens, constant in the so-called female flowers, become hypertrophied under the influence of the parasite without forming pollen and without developing any of the staminal characters latent in the normal state.

[110] *Naturw. Wochenschr., N. F.*, vol. XI, 1912.

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Table of Contents

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